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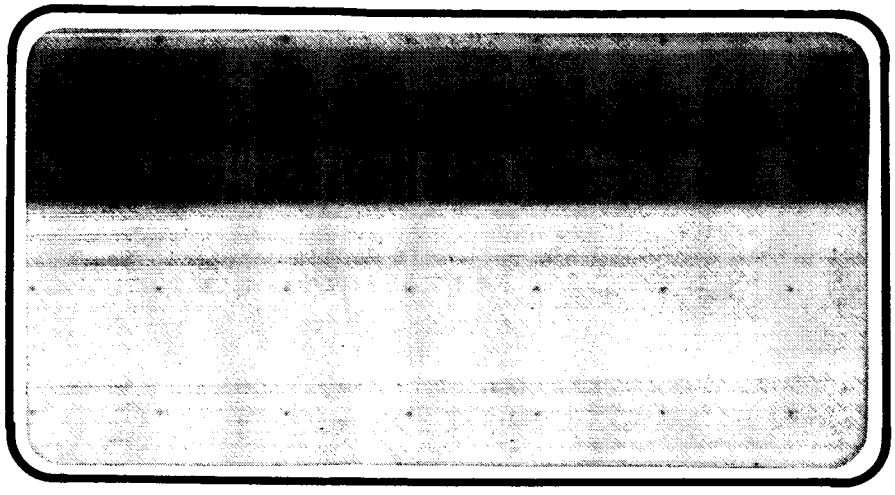
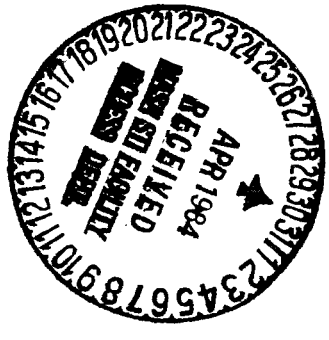


SPACE SHUTTLE AEROTHERMODYNAMIC DATA REPORT



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March 1984

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NASA-CR-167,684

POST-TEST DATA REPORT FOR THE SPACE SHUTTLE FULL-SCALE AFRSI SEQUENCE OF ENVIRONMENTS TEST (OS-305-1 TO -5) IN THE NASA/AMES RESEARCH CENTER 11x11-FOOT WIND TUNNEL

by

B. A. Marshall
Rockwell International
Space Transportation & Systems Group

Prepared under NASA Contract Number NAS9-16283

by

Data Management Services
Chrysler Huntsville Electronics Division
Michoud Engineering Office
New Orleans, Louisiana 70189

for

Systems Engineering Division

Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas

WIND TUNNEL TEST SPECIFICS:

Test Number:	ARC 562-1-11	ARC 562-2-11	ARC 562-3-11	ARC 562-4-11	ARC 562-5-11
NASA Series Number:	OS-305-1	OS-305-2	OS-305-3	OS-305-4	OS-305-5
Model Number of Test Fixture:	96-Ø	96-Ø	96-Ø	96-Ø	96-Ø
Test Start Date:	12-20-82	1-27-83	3-3-83	4-11-83	6-11-83
Test Completion Date:	12-22-82	1-27-83	3-3-83	4-11-83	6-11-83
Occupany Hours;	40	17	20.5	16	12
Model Number:	125-0 (ND-14-4)	125-0 (ND-14-4)	125-0 (ND-14-4)	125-0 (ND-14-4)	125-0 (ND-14-4)

FACILITY COORDINATOR:

J.J. Brownson
Mail Stop 227-5
Ames Research Center
Moffett Field, CA 94035
(415) 965-5647

PROJECT ENGINEERS:

R.B. Kingsland (AC07,2695) - Test
B.A. Marshall (AC07,2695) - Test

Rockwell International
Space Transportation & Systems Group
12214 Lakewood Blvd.
Downey, CA 90241

DATA MANAGEMENT SERVICES:

Approved: J. L. Glynn
J.L. Glynn, Manager
Data Operations

Concurrence: N. D. Kemp
N. D. Kemp, Manager
Data Management Services

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POST-TEST DATA REPORT FOR THE SPACE SHUTTLE FULL-SCALE AFRSI SEQUENCE OF ENVIRONMENTS TEST (OS-305-1 TO -5) IN THE NASA/AMES RESEARCH CENTER 11X11-FOOT WIND TUNNEL

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ABSTRACT

A five-part experimental investigation (OS-305-1 to -5) was conducted in NASA/Ames Research Center (ARC) 11x11-foot Wind Tunnel during the period between December 1982 and June 1983. Test OS-305-1 was conducted from December 20, 1982 to December 22, 1982. Test OS-305-2 was conducted on January 27, 1983. Test OS-305-3 was conducted on March 3, 1983. Test OS-305-4 was conducted on April 11, 1983 and Test OS-305-5 was conducted on June 11, 1983. One Advanced Flexible Reusable Surface Insulation (AFRSI) test article (Model 125-0/ND-14-4) was wind tunnel tested using the 96-0 test fixture during each of the five entries. The purpose of Test OS-305 was to expose the AFRSI to a simulated ascent airloads environment and obtain data which could be used to support the AFRSI certification program.

Test OS-305 was part of the AFRSI sequence of environments program which also included radiant heating (1500 degrees Fahrenheit) and wind/rain environments. The test article was wind/rain conditioned before each wind tunnel entry and was thermally conditioned after each wind tunnel entry. It should also be noted that Test OS-305 was originally scheduled for six entries in the ARC 11x11-foot Wind Tunnel. During Test OS-305-5, however, the AFRSI failed and the test was aborted before reaching the ascent environment. Prior to Test OS-305-5, the AFRSI test article had been sequentially exposed to 50 wind/rain and 49 simulated entry thermal missions, as well as four wind tunnel entries equivalent to 40 ascent missions.

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INTRODUCTION

Advanced Flexible Reusable Surface Insulation (AFRSI) is presently being used as a replacement for most of the Low-Temperature Reusable Surface Insulation (LRSI) tiles on the Space Shuttle Orbiter Vehicle. The AFRSI is a quilted blanket consisting of silica fiber felt insulation material with a quartz thread stitched through the three layers of material. The blanket IML is bonded to the skin of the vehicle while the OML face is exposed to the high-pressure gradients, fluctuating acoustic pressures, and the wind shear stresses attendant to atmospheric flight. The blankets are pliable, but individual fibrous elements are hard and brittle, and susceptible to damage, especially where they cross each other.

The purpose of Test OS-305 was to expose the AFRSI to a simulated ascent airloads environment and obtain data which could be used to support the AFRSI certification program. The test was conducted using the 96-O test fixture at Mach numbers varying from 0.80 to 0.88 and dynamic pressures of 683 to 761 psf. The leading edge flap of the test fixture was fixed at 18 degrees during the entire test. The aerodynamic shock environment created by the 96-O test fixture in the ARC 11x11-ft Wind Tunnel was an expansion/recompression shock which simulated the upper canopy flow field.

Test OS-305 was conducted during the course of five entries in the ARC 11x11-foot Wind Tunnel. Only one AFRSI test article (Model 125-O/ND-14-4) was tested during each entry. The test article was wind/rain conditioned before each wind tunnel exposure and thermally conditioned after each wind tunnel exposure.

During each of the five phases of Test OS-305, local fixture static pressures on each side of the test article were measured and recorded and Kulite dynamic data were obtained.

All test objectives were met. This report contains information on the conduct of Test OS-305, descriptions of the test fixture, test facility and instrumentation, and pressure data collected during the test. Photographs of the test fixture and the AFRSI test article are also included.

NOMENCLATURE

Symbol	Definition
C_p	Pressure Coefficient
dB	Volume of sound (decibel)
^oF	Degrees Fahrenheit
FT	Feet
HR	Hour
HZ	Hertz (cycles per second)
IN	Inches
in. Hg, "Hg	Inches of Mercury
K	Kulite
M, M_∞	Freestream Mach Number
MIN	Minutes (increment of time)
MM	Millimeters
P, P_∞	Freestream static pressure, psia
P_{RMS}	Root Mean Square (RMS) pressure in psia
PSF, psf	Pounds per square foot
psi	Pounds per square inch
psia	Absolute pressure, psi
PT	Freestream total pressure, psia
Q, q_∞, q	Freestream dynamic pressure, psf
^oR	Degrees Rankine
Sec	Seconds (increment of time)
sq. ft.	Square feet
X	Longitudinal distance positive, inches aft of test surface leading edge
Y	Lateral distance positive, inches right of fixture centerline

Other Symbology Includes:

Symbol	Definition
AFRSI	Advanced Flexible Reusable Surface Insulation
ALUM.	Aluminum
ARC	Ames Research Center
AVG.	Average
BLKT(s)	Blanket(s)
CARR PL	Carrier Plate
Cert.	Certification
CHR	Chromel
Cond.	Condition
DIA.	Diameter
F/B	Filler Bar
FRSI	Flexible Reusable Surface Insulation
FWD	Forward
G/F	Gap Filler
IML	Inner Mold Line
L.E., L/E	Leading Edge
LRSI	Low Temperature Reusable Surface Insulation
NA	Not Applicable
NASA	National Aeronautics and Space Administration
NDE	Nondestructive Evaluation
No.	Number
OML	Outer Mold Line
RTV	Room-Temperature Vulcanized

Symbol	Definition
SHTS	Sheets
SIP	Strain Insulator Pad
STD.	Standard
SURF.	Surface
T/A	Test Article
T/C	Thermocouple
TUNN.	Tunnel
TYP.	Typical
@	At

REMARKS

Test OS-305 was originally scheduled for six entries in the ARC 11x11-foot Wind Tunnel. During Test OS-305-5, however, the AFRSI failed and the test was aborted before reaching the ascent environment. Prior to Test OS-305-5, the AFRSI test article had been sequentially exposed to 50 wind/rain and 49 simulated entry thermal missions, as well as four wind tunnel entries equivalent to 40 ascent missions. Table III shows all of the tests which were run on the ND-14-4 test article.

It should also be noted that gap fillers were added to the ND-14-4 test article after the completion of Test OS-305-1 as shown in Figure 1d.

CONFIGURATIONS INVESTIGATED

MODEL DESCRIPTION

The 96-O test fixture was used for Test OS-305. The fixture, depicted in Figure 1a, functions to cause an expansion shock pattern ahead of the test article, followed by a recompression shock region with attendant positive pressure gradients and high turbulence levels over the test article.

The mechanism employed to produce the desired expansion/recompression shocks was a full-span, 15-inch chord flap located at the forward end of the test panel. The flap was originally designed to rotate through angles of zero to 30 degrees by a remotely controlled hydraulic actuator. For this test, a turnbuckle replaced the hydraulic cylinder and was adjusted to lock the flap at 18 degrees.

The fixture had end plates to make the flow field in the test area two dimensional. The end plates (98x56 inches) extended from a height of three feet above the top of the test panel all the way to the floor, and were supported from underneath. The beveled leading edges were located 26 inches forward of the test specimen's leading edge.

A sealed pressure box enclosed the area under the panel. The box was vented to the tunnel plenum for this test. Also, shims and spacers were available for the test article to bring its leading edge flush with the surface of the fixture.

TEST ARTICLE

Model 125-0 designates one test article which was made up of a support plate, the AFRSI bonded to the support plate, and a frame which protected and held the AFRSI edges. When installed, the frame of the test specimen was flush with the adjacent surface of the fixture to the extent possible, particularly at the leading edge. Figure 1c illustrates the configuration.

INSTRUMENTATION

Data recorded during Test OS-305 were measured by static pressure orifices and dynamic pressure transducers (Kulites).

The 96-0 test fixture was instrumented with 28 peripheral static pressure orifices. The locations are shown in Figure 1b and listed in Table V. Data from these taps were recorded during all runs.

The static pressure ports were connected to six Scanivalves (one six-pack). Rockwell furnished all necessary tubing, Scanivalves, and transducers.

In addition, the 96-0 test fixture was instrumented with fourteen Kulite transducers to measure peripheral fluctuating pressures. Their locations are shown in Figure 1b and listed in Table V.

The reference tube of all Kulites were connected to a common manifold which was vented to the tunnel static pressure. Rockwell supplied the transducers and associated cabling.

All power supplies and signal conditioning equipment associated with the Kulite transducers were supplied by ARC. Tunnel static pressure was recorded on tape with the Kulite data.

TEST FACILITY DESCRIPTION

The NASA Ames 11-foot Transonic Wind Tunnel is the transonic leg of the Ames Unitary facility. It is a closed circuit, single return, continuous flow, variable-density tunnel. The 11x11x22-foot test section is slotted to permit transonic testing. The nozzle has adjustable sidewalls. The tunnel air is driven by a 3-stage axial flow compressor powered by four wound-rotor induction motors. The speed of the motors is varied as necessary to provide the desired Mach number. The motors have a combined output of 180,000 horsepower for continuous operation or 216,000 horsepower for one hour. Tunnel temperature is controlled by aftercoolers and a cooling tower. Four 30,000 cubic-foot storage tanks provide dry air for tunnel pressurization.

The tunnel can be operated at nominal Mach numbers of 0.5 to 1.4, unit Reynolds numbers of 1.7 to 9.4 x 10^{+6} per foot, dynamic pressures of 150 to 2000 (psf) and a total temperature of 540 to 610 (^{o}R), respectively.

This tunnel is used for force and moment, pressure, internal air flow/inlet and dynamic-stability tests.

TEST PROCEDURES

During each of the five phases of Test OS-305, the ND-14-4 test article was exposed to the minimum number of ascent missions possible. After the test article was inspected and the tunnel door was closed, the tunnel was pumped down to 28 inches of Mercury for a scanivalve check. The tunnel was then pumped up to 33 inches of Mercury and the tunnel drive was started. Next, the television and Kulite recorders were turned on and static pressures were recorded continually as the tunnel was being brought to M = 0.88.

When q reached 400 psf, the ascent environment exposure time was started. The Mach number was increased as fast as possible until M = 0.88 and a steady state static pressure data point was taken. Next, a fast stop was initiated and the ascent environment exposure time was stopped at q = 400 psf. The Kulite and television recorders were then turned off and the test article was inspected after the tunnel door was opened.

The amount of time that q was above 400 psf during each of the first four phases of OS-305 was approximately four minutes. Four minutes above q = 400 psf is equivalent to 40 ascent missions (10 missions with a scatter factor of 4). As a result of OS-305-5, however, the AFRSI failed and the test was aborted prior to reaching the ascent environment. No additional ascent missions were accumulated during Test OS-305-5. Table III shows the test chronologies for all five phases of Test OS-305.

A summary of the test conditions for Test OS-305 is shown in Table I. A summary of the runs completed during Test OS-305 is shown in Table II.

DATA REDUCTION

Standard tunnel equations were used for computing all tunnel conditions. All local standard pressure data were reduced to standard pressure coefficient form using the following equation:

$$Cp = \frac{P_L - P \times 144}{q}$$

Fluctuating pressure data were recorded on magnetic tape and reduced during and after the test.

Local sound pressure levels were calculated as follows:

$$dB = 20 \log \frac{P_{RMS}}{2.94 \times 10^{-9}}$$

REFERENCES

1. R. B. Kingsland, STS-82-0824, "Pretest Information for the AFRSI Full-Scale Certification ($T \leq 1500^{\circ}F$) Test OS-305 in the Ames Research Center (ARC) 11x11-foot Wind Tunnel using Model 125-O installed in the 96-O Test Fixture" (December 1982)

Table I

TEST : OS-305 DATE : 6-11-83

TEST CONDITIONS

MACH NUMBER	Total Pressure (pounds/sq. ft.)	Dynamic Pressure (pounds/sq. ft.)	
.55	2326	400	
.80	↓	683	
.82		704	
.84		723	
.86		743	
.88		761	

BALANCE UTILIZED: NA

	CAPACITY:	ACCURACY:	COEFFICIENT TOLERANCE:
NF			
SF			
AF			
PM			
RM			
YM			

COMMENTS:

RUN SUMMARY (OS-305)

AFRSI FULL-SCALE CERTIFICATION (T≤1500°F) TEST (MODEL 96-0) 11×11 ARC

TEST: OS-305 — **DATA SET/RUN NUMBER COLLATION SUMMARY** — **DATE: JUNE 1983**

Test No.	ARC 562-*-11 *	RUN No.	PARAMETERS/VALUES P_T	δ_F	MACH NUMBERS .60	.80	.82	.84	.86	.88	Time on Cond. MIN
			33" H_g	18							
305-1	1	3	✓	✓		✓	✓	✓	✓	(1) ✓	4
305-2	2	1	✓	✓		✓	✓	✓	✓	(1) ✓	4
305-3	3	2	✓	✓	✓						0.5
305-3	3	4	✓	✓		✓	✓	✓	✓	(1) ✓	4.5
305-4	4	2	✓	✓		✓	✓	✓	✓	(1) ✓	3.8
305-5	5	2	✓	✓	✓	✓	✓				0

Note: Time to start @ $q \geq 400$ psf

(1) Steady State Static Pressure Data Point

IDVAH 111 IDVAH 121 NDV

NASA-MSFC-MAF

OS 033

Table III

AFRSI SEQUENCED ENVIRONMENTS TESTS

MISSIONS PER TEST BLOCK

TEST BLOCK	THERMAL	WIND/RAIN*			WIND TUNNEL	FLIGHT CERT.
		A	B	C		
-1	0	1	-	-	9.5	1
-2	1	-	1	-	9.5	2
-3	5	3	2	-	12.2	3 → 7
-4	10	6	3	1	9.2	8 - 17
-5	33	26	6	1	0	—

*WIND/RAIN TEST CRITERIA

CYCLE	TIME (MIN)	RAIN (IN/HZ)	DROP SIZE (MM AVG)	WIND (KNOTS)	TOTAL RAIN (IN)
A	65	3.5	≤ 1	NONE	3.79
B	26	8.7	2	6.4	3.77
C	10	21	≥ 2	50.4	3.5

TABLE IV

OS-305 TEST CHRONOLOGY

Test OS-305-1 Chronology for Test Article ND-14-4 on: December 22, 1982

Clock Hr:Min:Sec	Exposure Min: Sec	Event
15:38:00		Drive Start
15:40:38	0:0	q = 400 psf, P_T = 33 in. Hg, start exposure time
15:44:24	3:46	M = 0.89, took steady state data point; began fast stop procedures
15:44:38	4:00	q = 400 psf, P_T = 33 in. Hg, end exposure time

TABLE IV (Continued)

OS-305 TEST CHRONOLOGY

Test OS-305-2 Chronology for Test Article ND-14-4 on: January 28, 1983

Clock Hr:Min:Sec	Exposure Min:Sec	Event
18:09:00		Drive Start
18:11:52	0:0	q = 400 psf, P_T = 33 in. Hg, start exposure time
18:15:22	3:30	M = 0.88, took steady state data point; began fast stop procedures
18:15:55	4:03	q = 400 psf, P_T = 33 in. Hg, end exposure time

TABLE IV (Continued)

OS-305 TEST CHRONOLOGY

Test OS-305-3 Chronology for Test Article ND-14-4 on: March 3, 1983

Clock		On Condition	Event
Hr:Min:Sec		Min:Sec	
Run 2			
21:34			Drive Start
21:36:58		0:00	q > 400 psf
21:37:20		0:38	M = 0.6 Initiate Fast Stop-Facility Problem
Run 4			
22:42			Drive Start
22:45:46		0:00	q > 400 psf
49:20		3:34	M = 0.89; Steady State Data
50:16		4:30	q > 400 psf
	TOTAL	5:08	

TABLE IV (Continued)

OS-305 TEST CHRONOLOGY

Test OS-305-4 Chronology for Test Article ND-14-4 on: April 11, 1983

Clock Hr:Min:Sec	Exposure Min:Sec	Event
23:28:00		Drive Start
23:30:30	0:0	q = 400 psf, P_T = 33 in. Hg, start exposure time
23:33:55	3:25	M = 0.88, took steady state pressure point; began fast stop procedures
23:34:21	3:51	q = 400 psf, P_T = 33 in. Hg, end exposure time

TABLE IV (Continued)

OS-305 TEST CHRONOLOGY

Test OS-305-5 Chronology for Test Article ND-14-4 on: June 11, 1983

No.	Time	M/f	Remarks
1	21:15:00	-	Start (Note: P_T 33 psi @ 21:14:22).
2	21:15:25	-	Start drive.
3	21:20:00	0.34	No change.
4	21:21:00	0.50	Initial NDE breach blanket number 7 increase.
5	21:22:23	0.55	Q = 400 psf
6	21:23:05	0.65	Initial breaches in blanket numbers 1 and 7 increase in size.
7	21:23:28	0.70	Leading edge face sheet of blanket number 7 "opened" in initial breach area.
8	--	-	More blanket number 7 L/E, face sheet leaving.
9	--	-	Initial breach, left rear, number 7 getting larger.
10	21:24:05	0.75	Face sheet is peeling back in above area.
11	--	-	Right rear number 7 face sheet leaving.
12	--	0.76	Closeout on blanket number 8 around tile is separating.
13	--	0.78	More face sheet L/E and AFT blanket number 7 leaving.
14	--	-	Initial breach, blanket number 1 center, increasing.
15	21:24:41	0.80	Initial breach blanket number 1 center, increasing.
16	--	-	Left edge, blanket number 2 face sheet and right leading edge start to peel.
17	--	-	Face sheet material, blanket number 1, leaving center and right side center.

NOTE: To this point no batting has left.

TABLE IV (Concluded)

OS-305 TEST CHRONOLOGY

No.	Time	M#	Remarks
18	--	-	Lost batting blanket number 1 center and number 7 AFT right.
19	--	-	Blanket number 1 center losing a lot of batting.
20	--	-	Blanket number 3 losing face sheet followed by losing most batting.
21	21:25:13	0.82	All blankets losing batting except number 4.
22	--	-	Face sheet on blanket number 4 is breaching.
23	21:25:15	-	Quick stop.
24	21:25:25	0.55	Shutdown in progress.
25	21:28:00	-	Tunnel down.

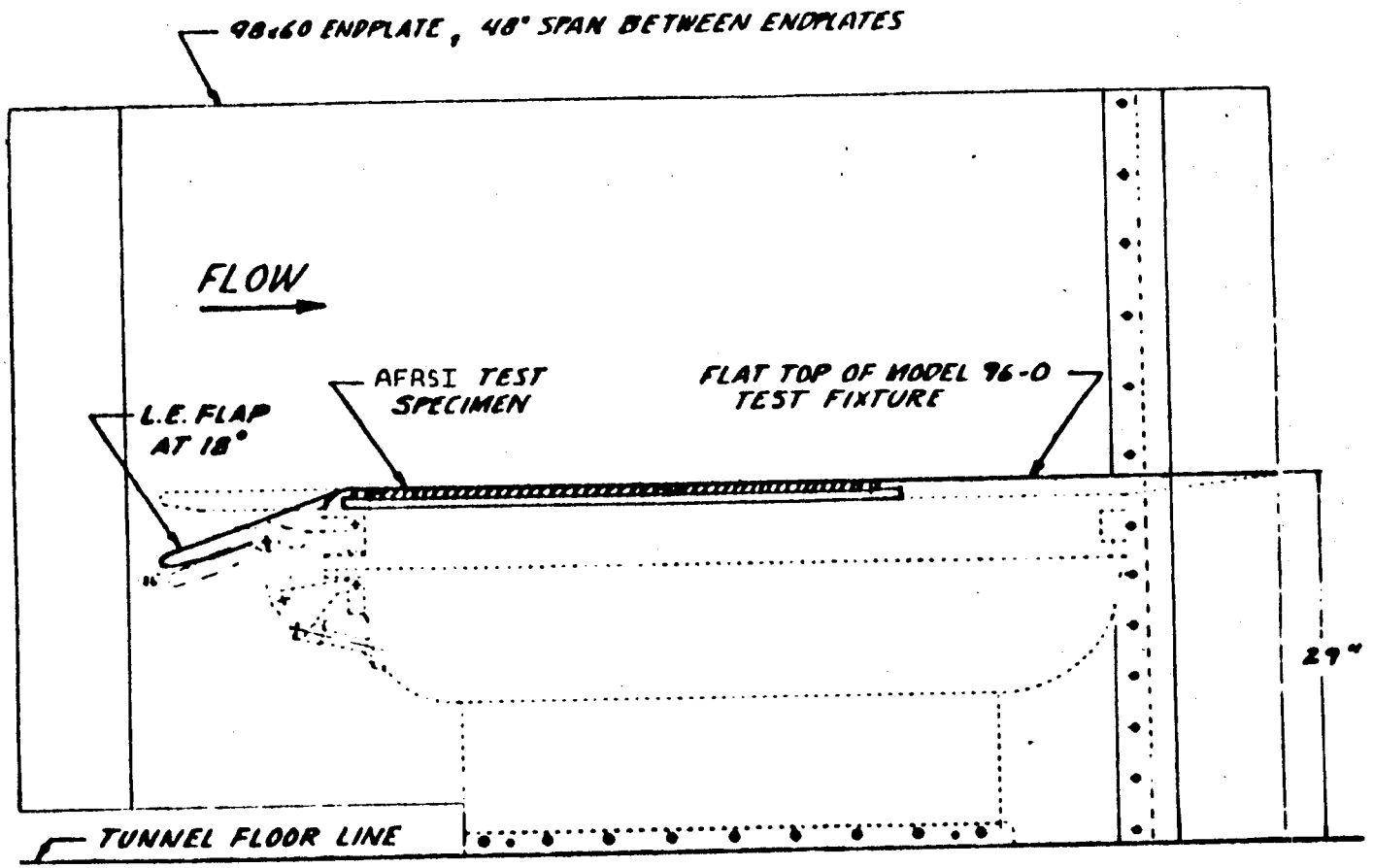
Notes: -Time from M 0.55 to blankets coming all apart @ M 0.82 = 2 min. 51 sec.

-Time from M 0.55 to M 0.55 during shutdown = 3 min. 2 sec.

-Start time sequence may not agree with actual time - intent for spacing only.

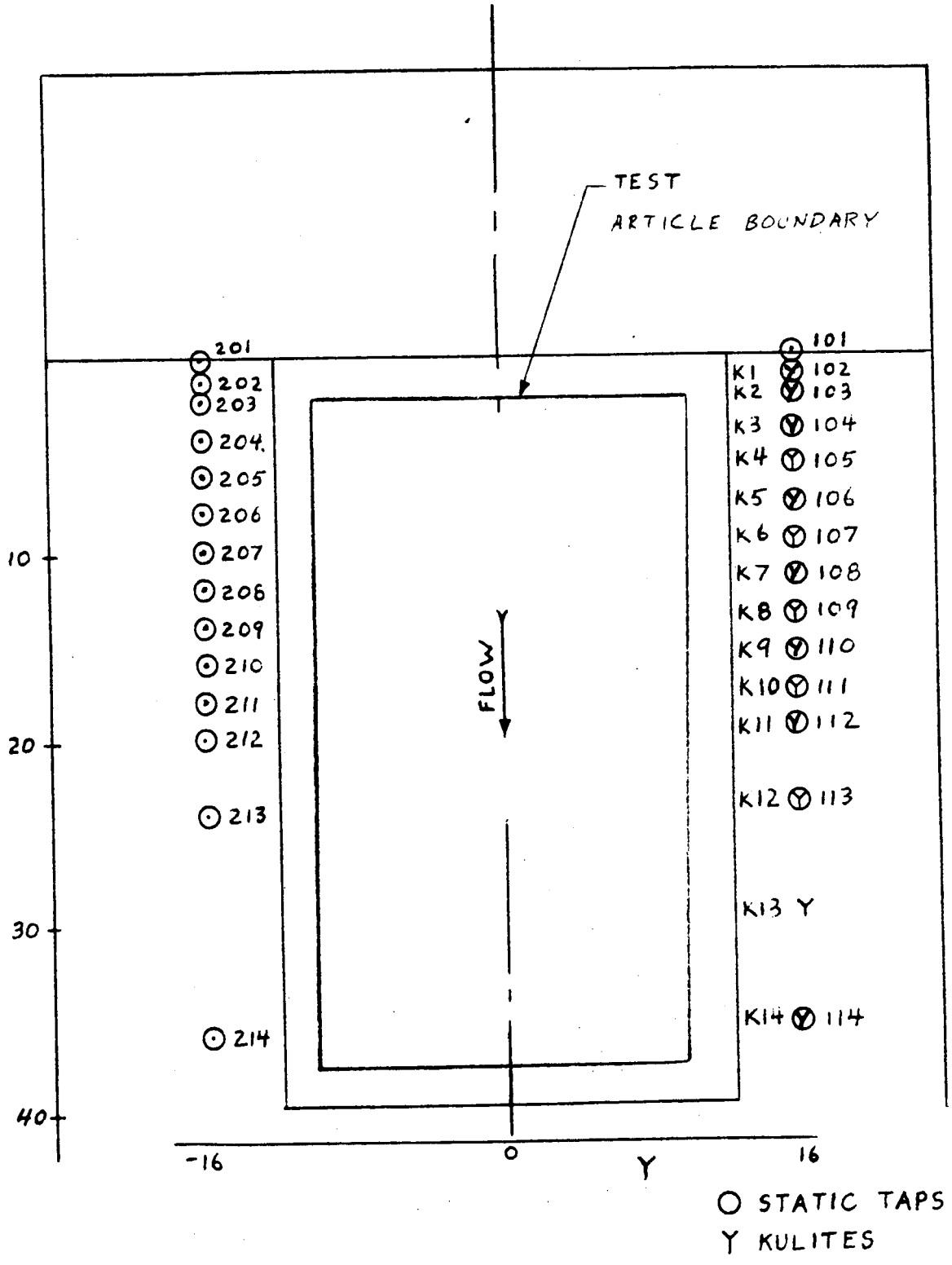
TABLE V, INSTRUMENTATION LOCATION, FIXTURE 96-0

X \ Y	STATIC TAPS						Kulites at Y=16
		-16		0		16	
0		201				101	
1		202				102	K1
2		203				103	K2
4		204				104	K3
6		205				105	K4
8		206				106	K5
10		207				107	K6
12		208				108	K7
14		209				109	K8
16		210				110	K9
18		211				111	K10
20		212				112	K11
24		213				113	K12
30							K13
36		214				114	K14



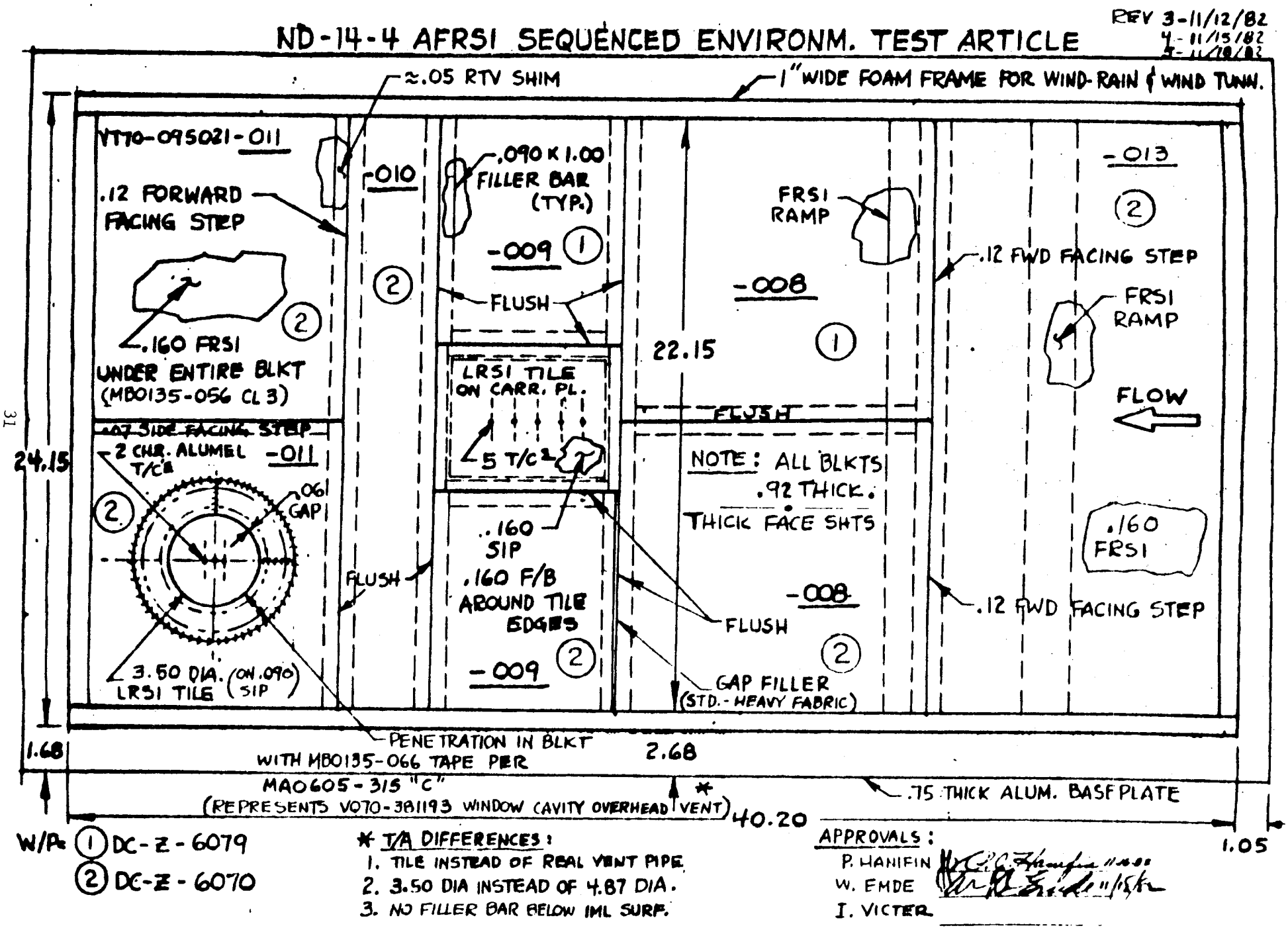
a. Model 96-0 Test Fixture General Arrangement for Test OS-305

Figure 1 Model Figures



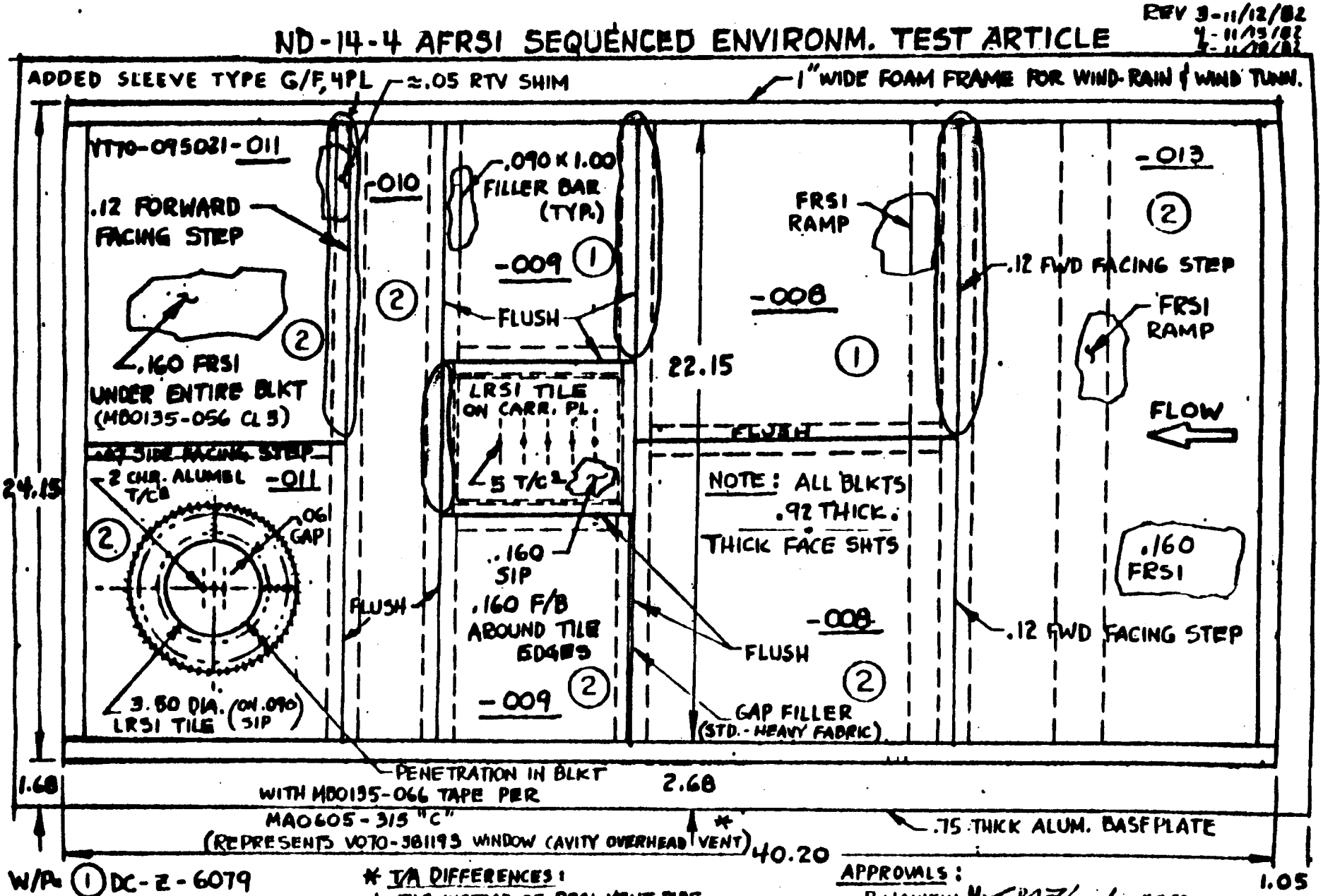
b. INSTRUMENTATION LOCATIONS FOR THE 96-0 TEST FIXTURE (OS-305)

Figure 1 Model Figures (continued)



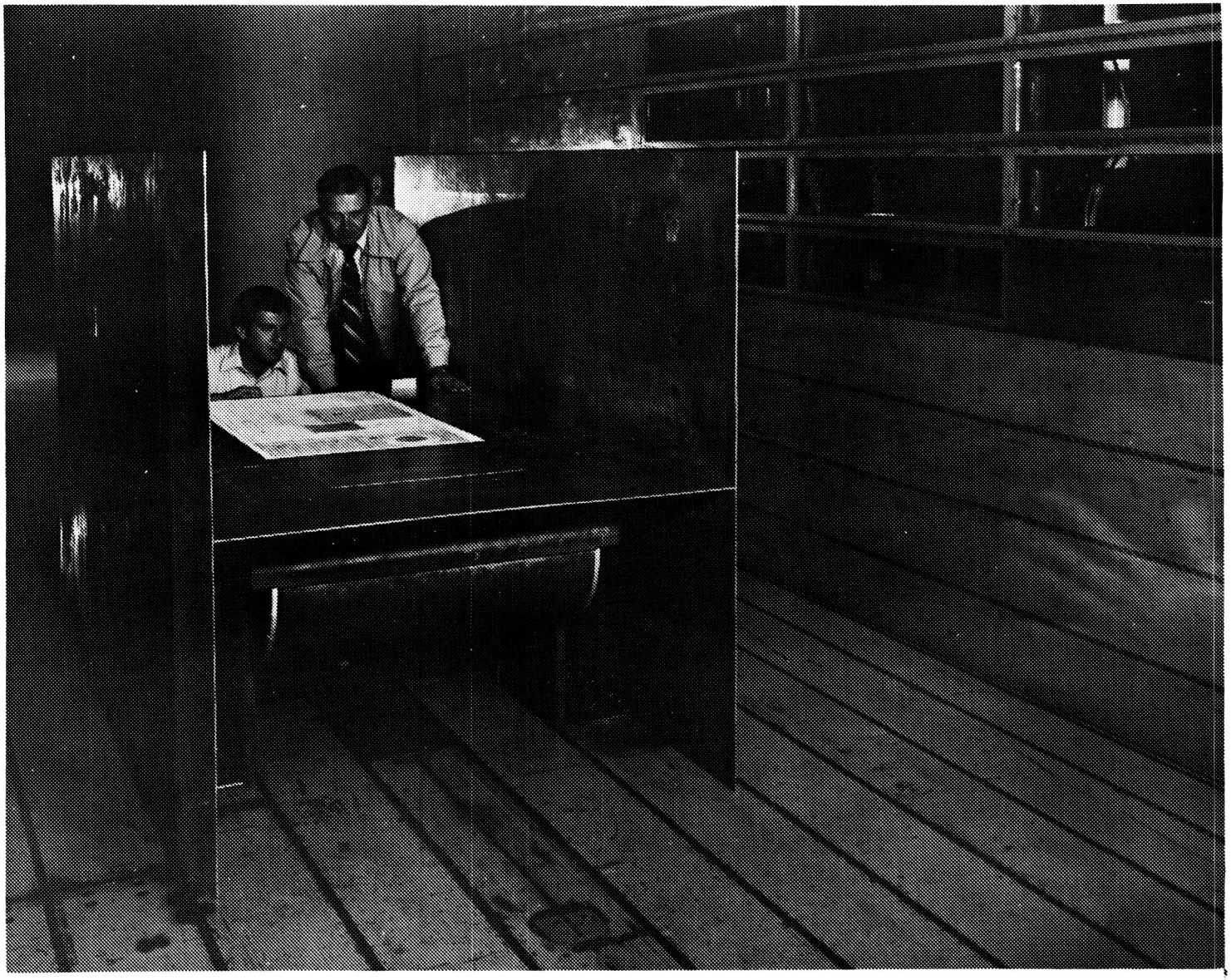
C. Model 125-0 Test Article

Figure 1 Model Figures (continued)



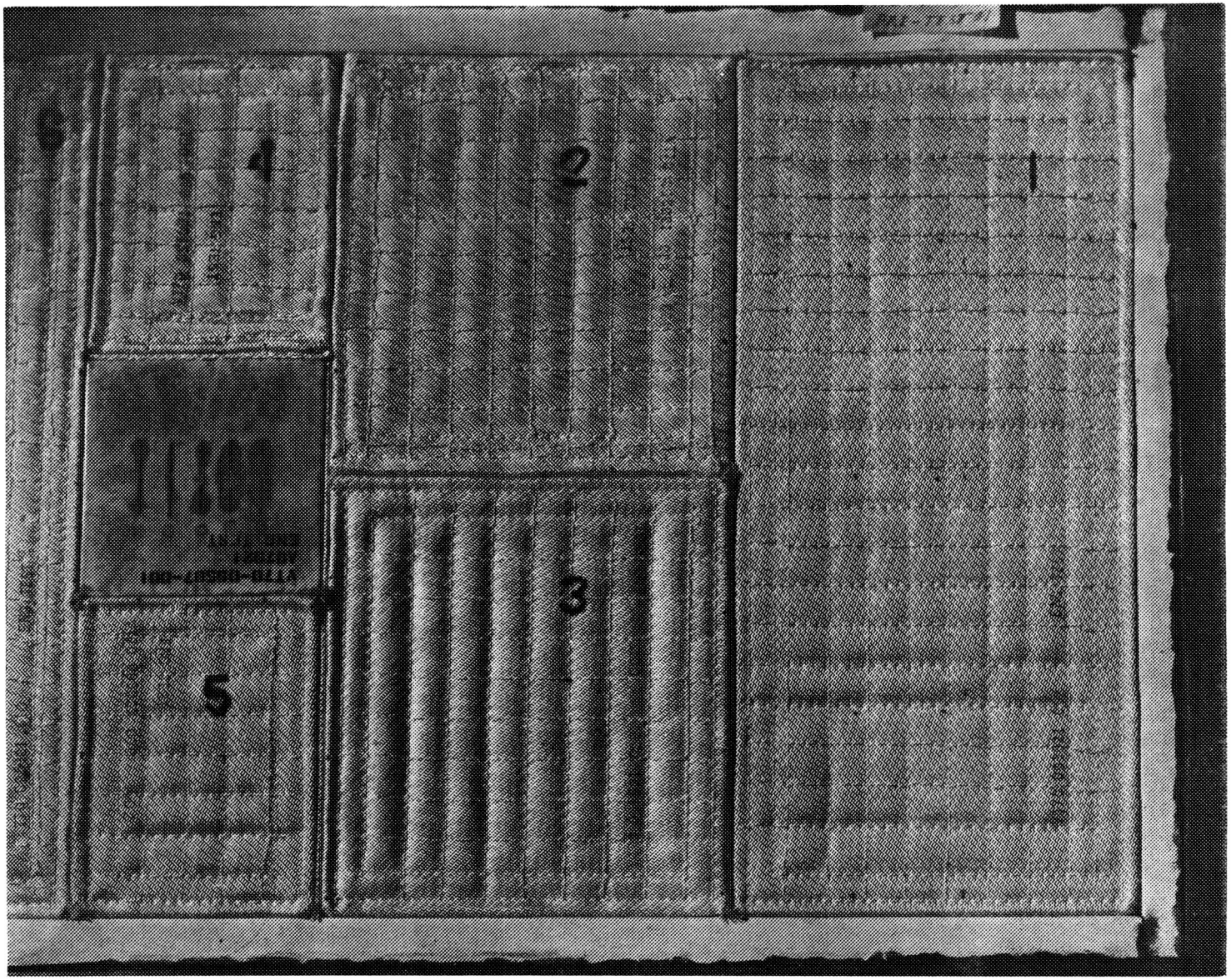
d. Model 125-0 Test Article

Figure 1 Model Figures (concluded)



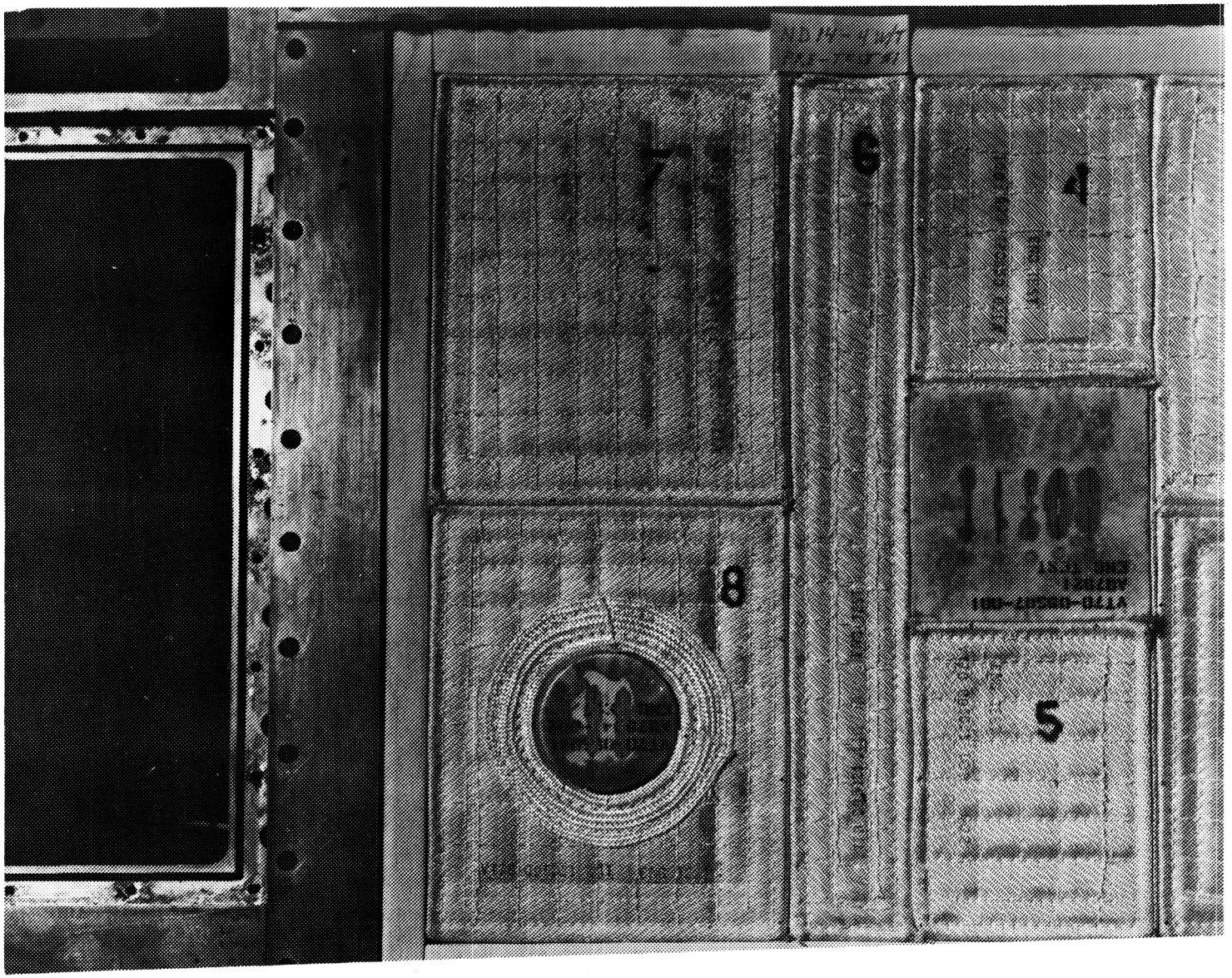
a. Pre-Test OS-305-1 Photograph of Model 125-0 (Test Article ND-14-4) installed in the 96-0 Test Fixture located in the NASA/ARC 11x11-ft Wind Tunnel

Figure 2. Model Photographs



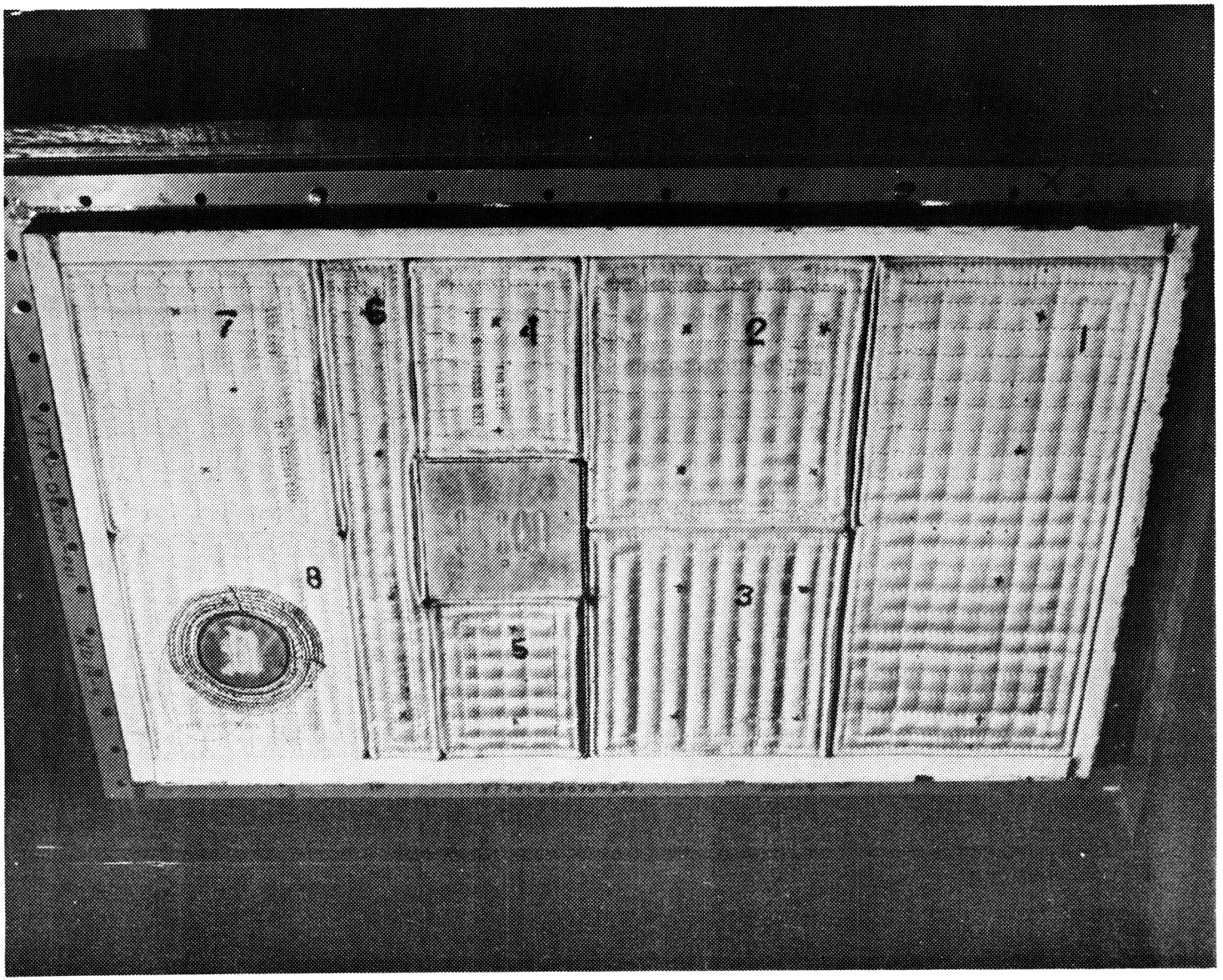
b. Pre-Test OS-305-1 close-up photograph of the forward portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



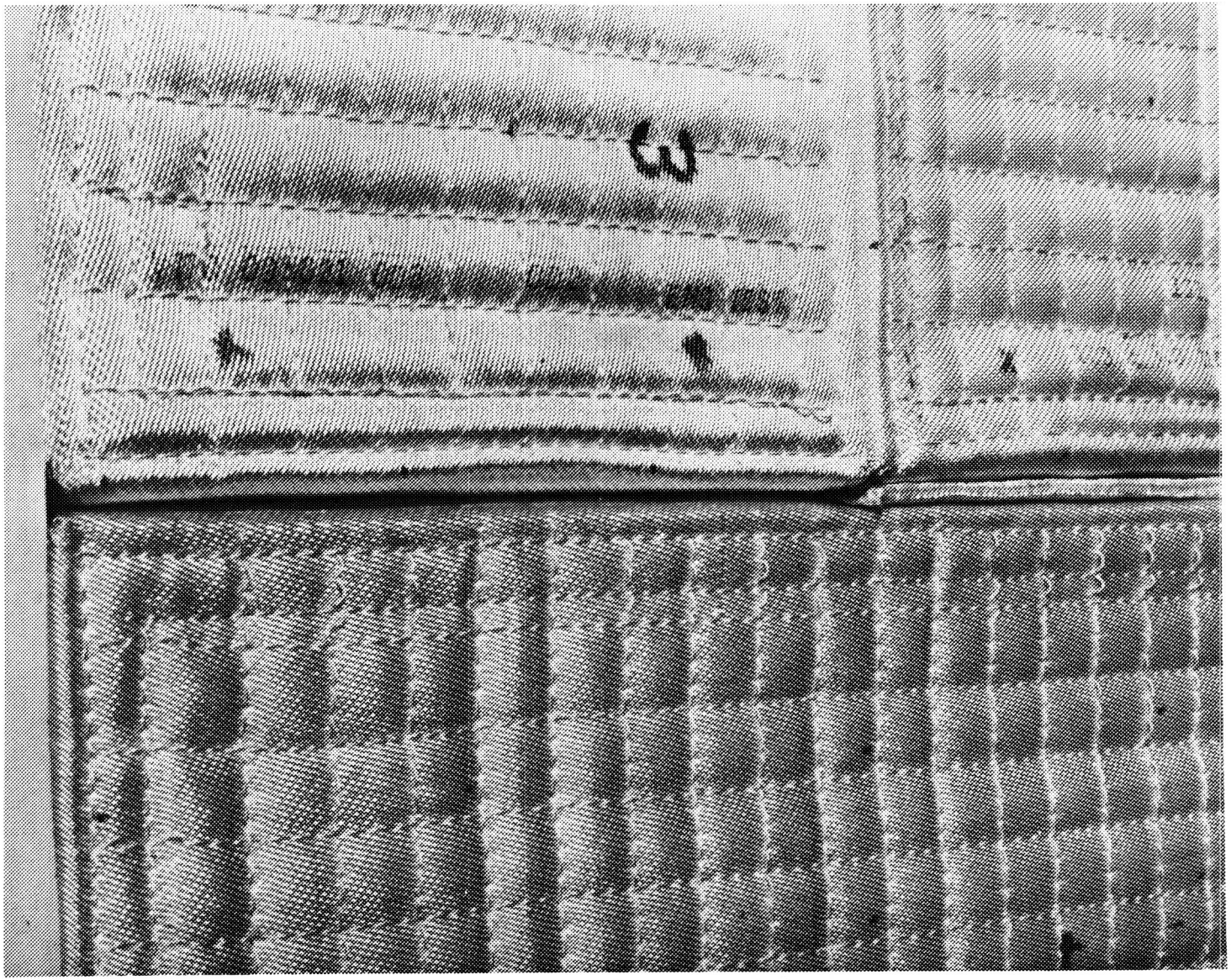
c. Pre-Test OS-305-1 close-up photograph of the aft portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)

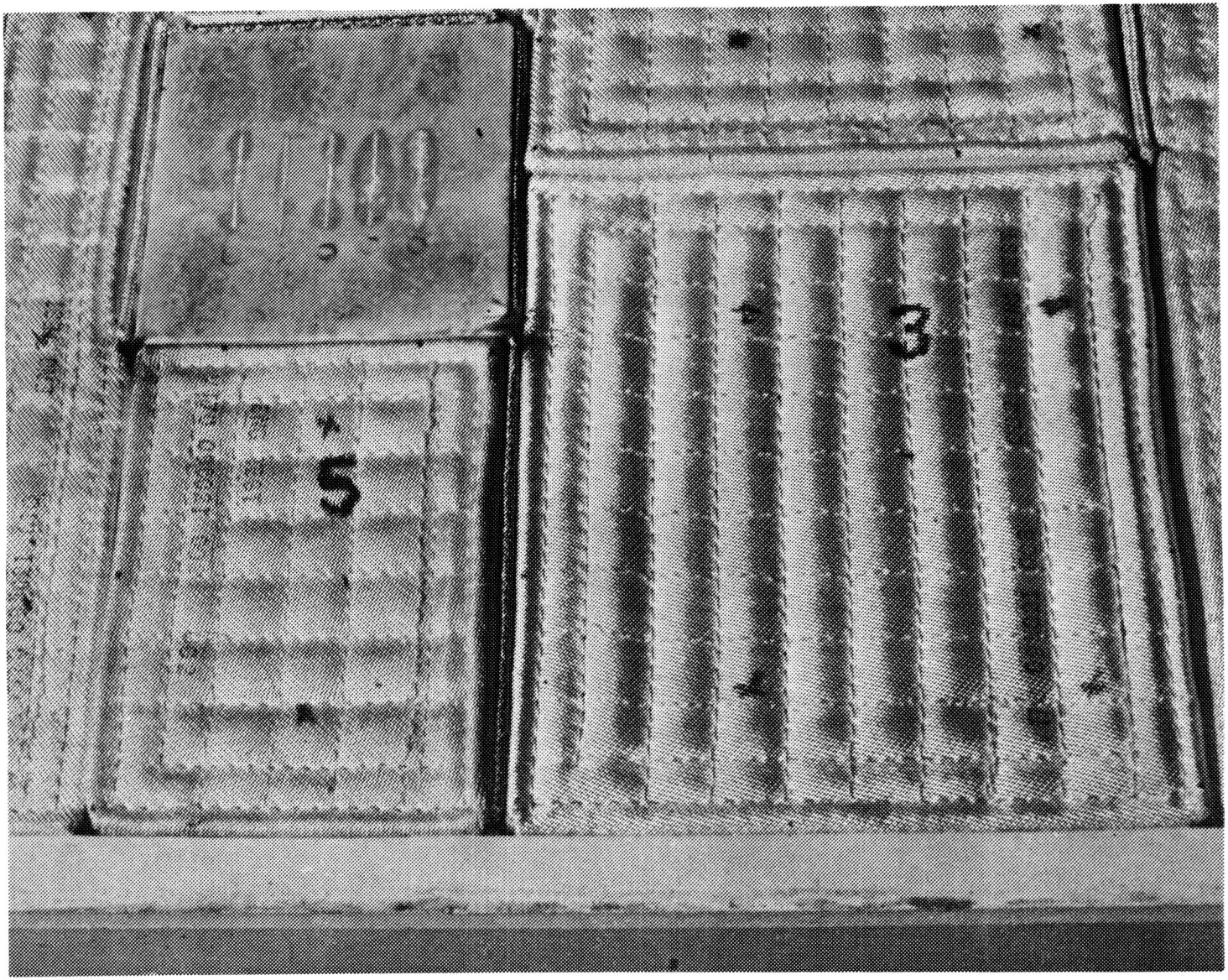


d. Post-Test OS-305-2 photograph of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)

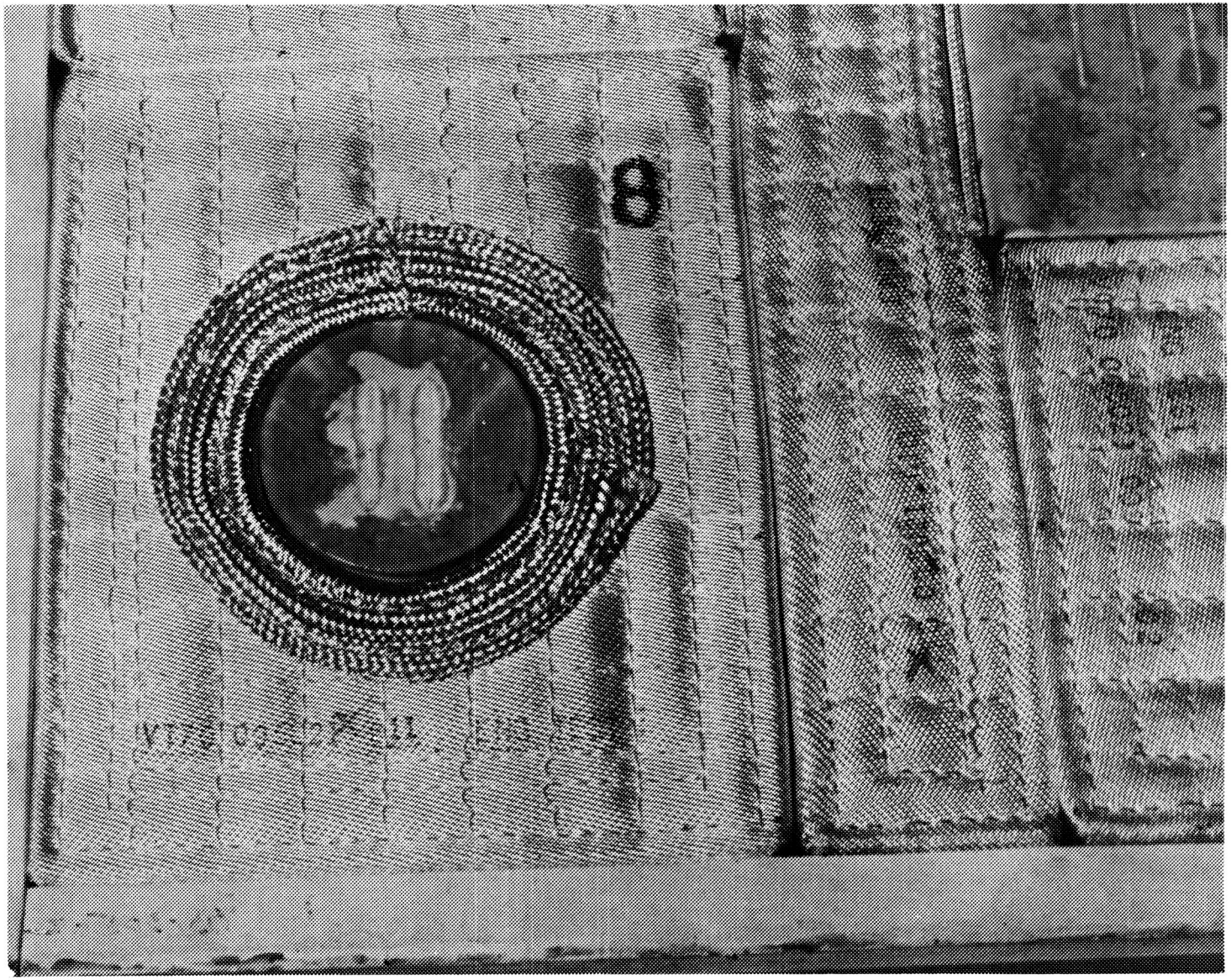


e. Post-Test OS-305-2 close-up photograph of the middle portion of Model 125-0 (Test Article ND-14-4)



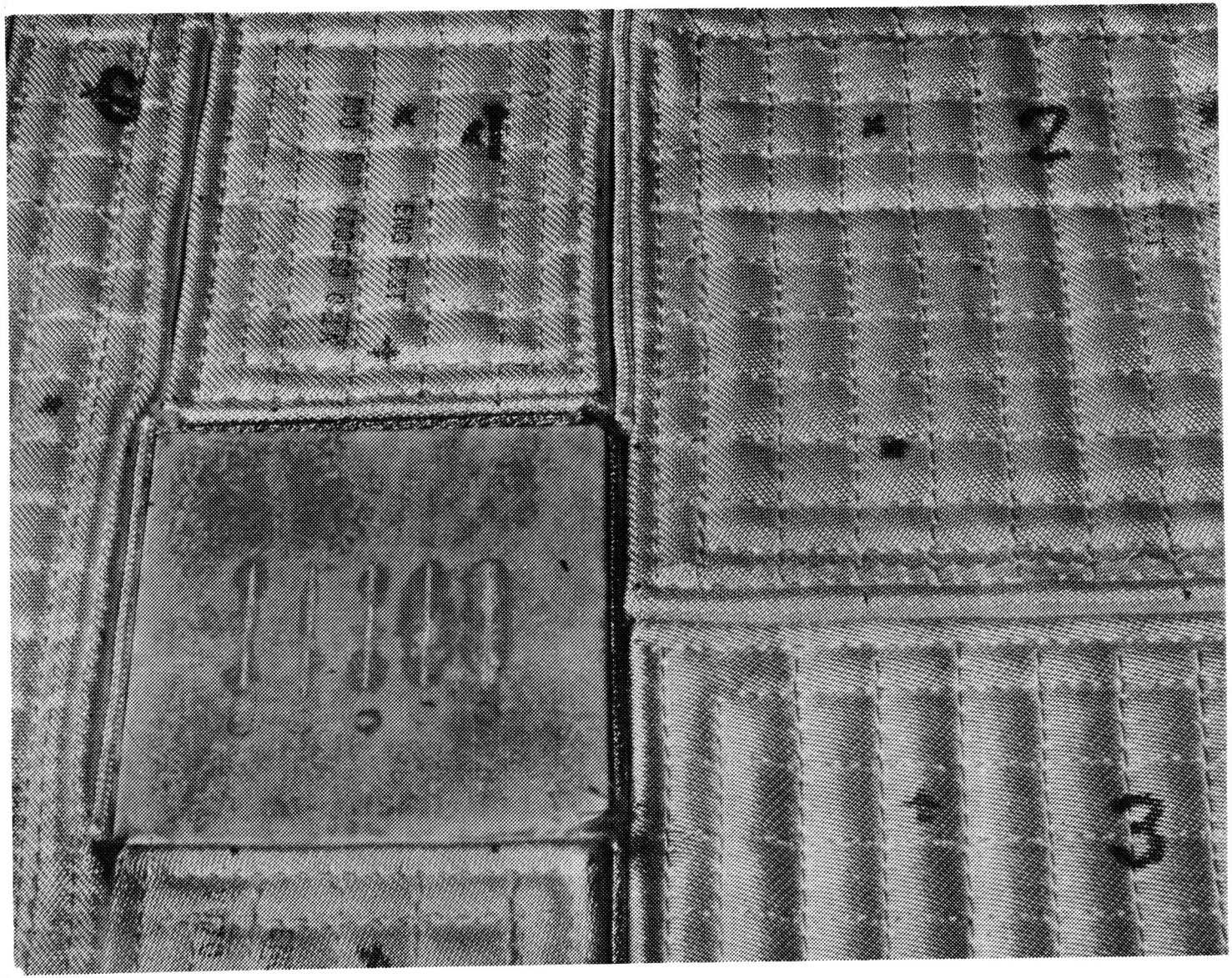
f. Post-Test OS-305-2 close-up photograph of the middle portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



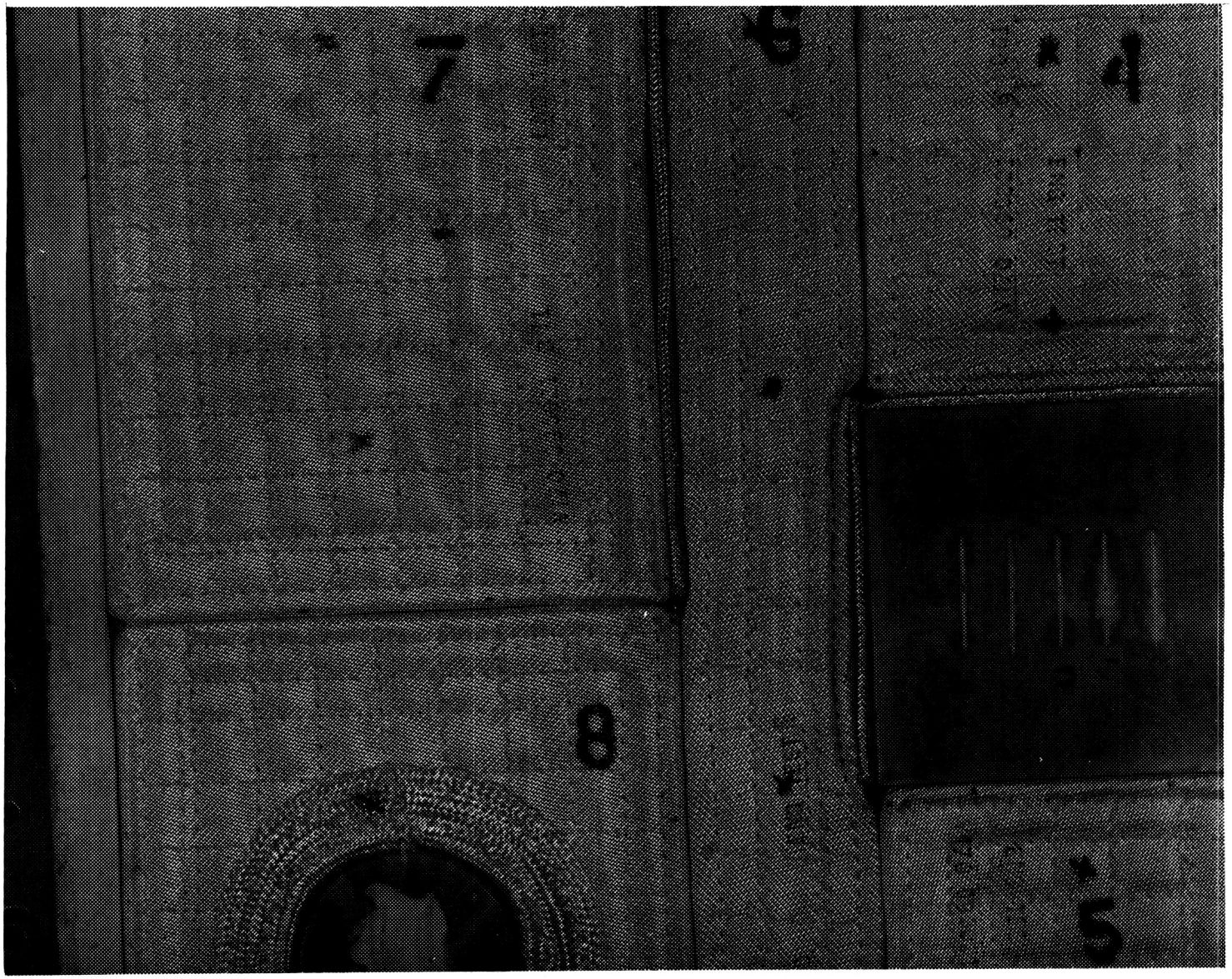
g. Post-Test OS-305-2 close-up photograph of the aft portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



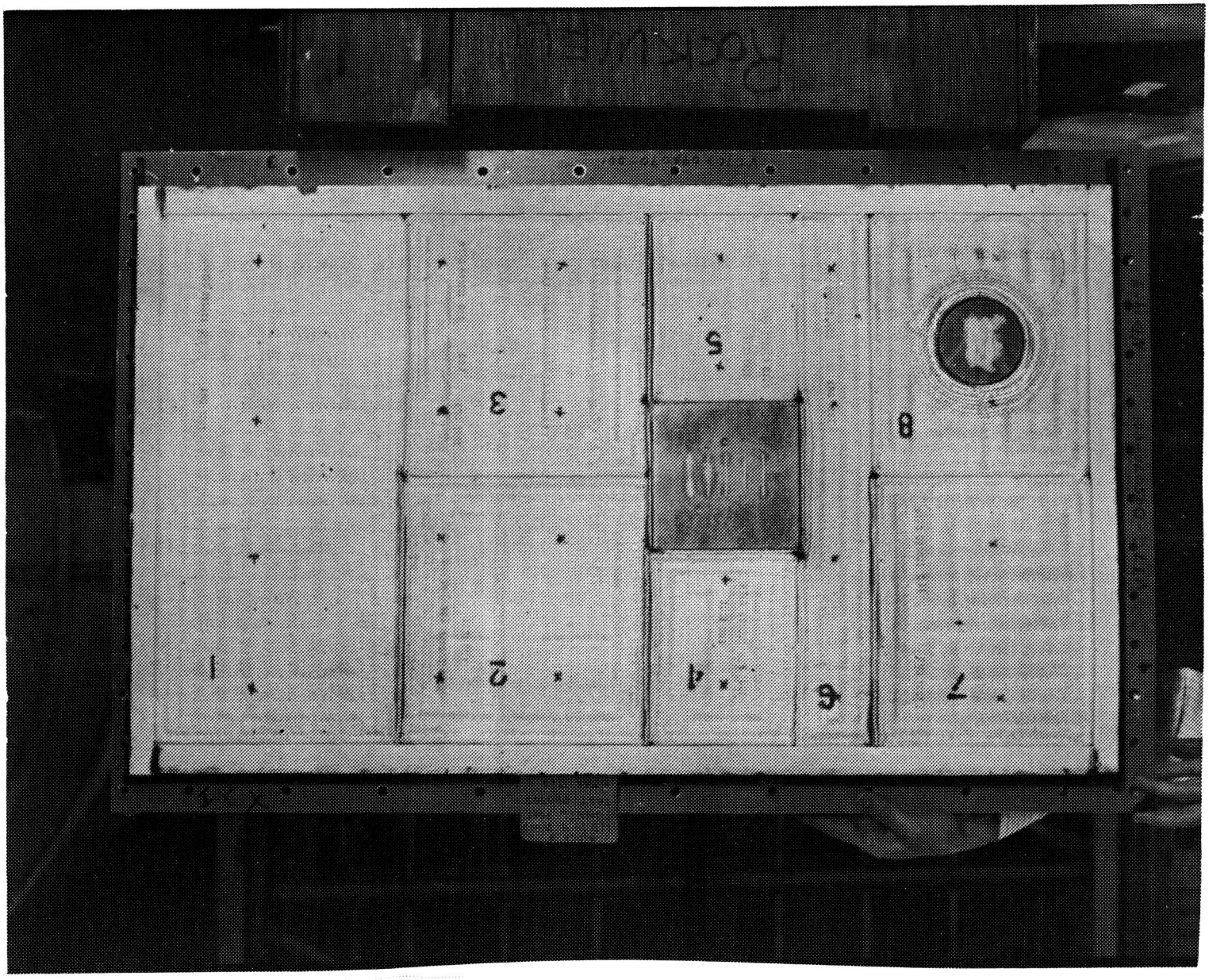
h. Post-Test OS-305-2 close-up photograph of the middle portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



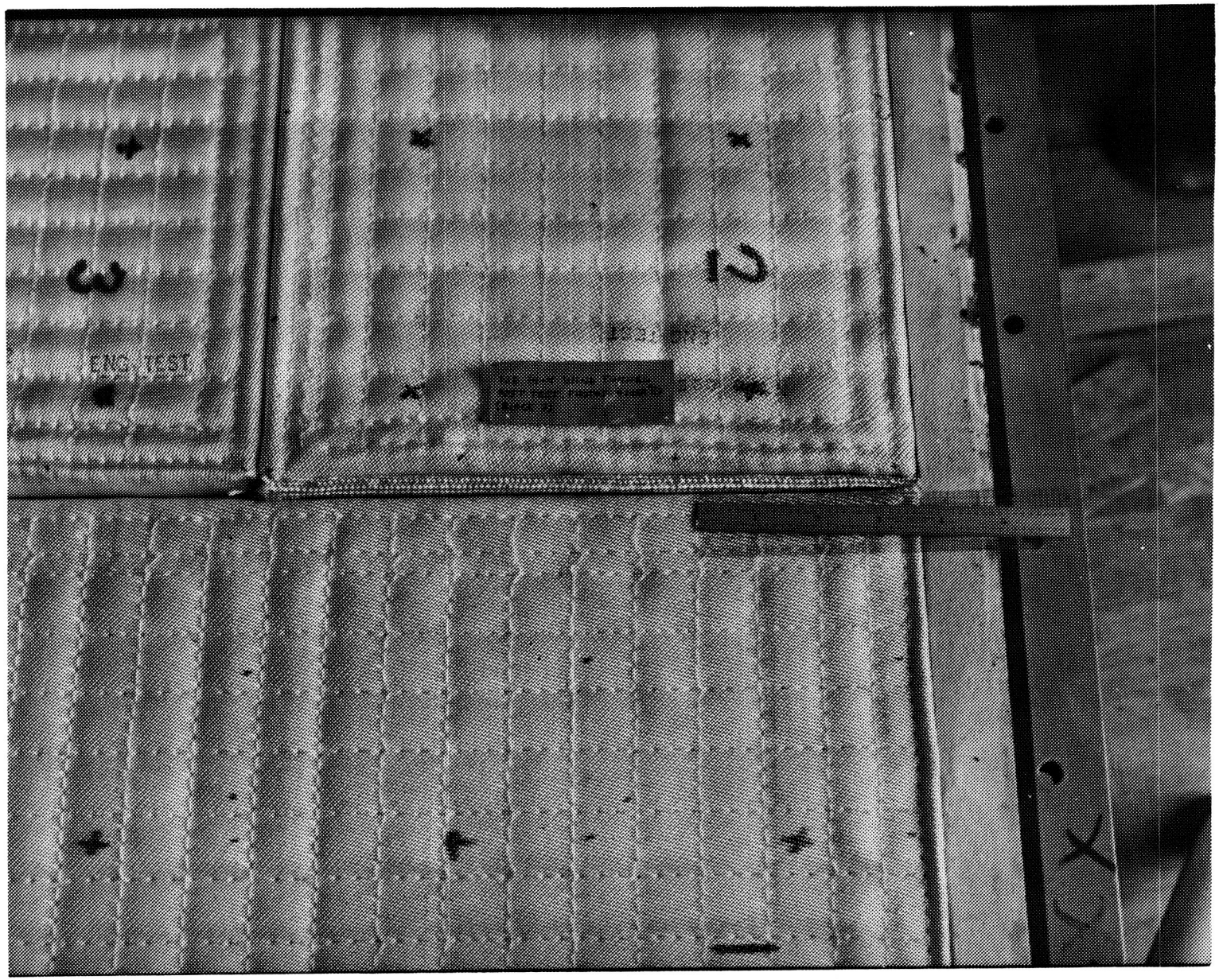
i. Post-Test OS-305-2 close-up photograph of the aft portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



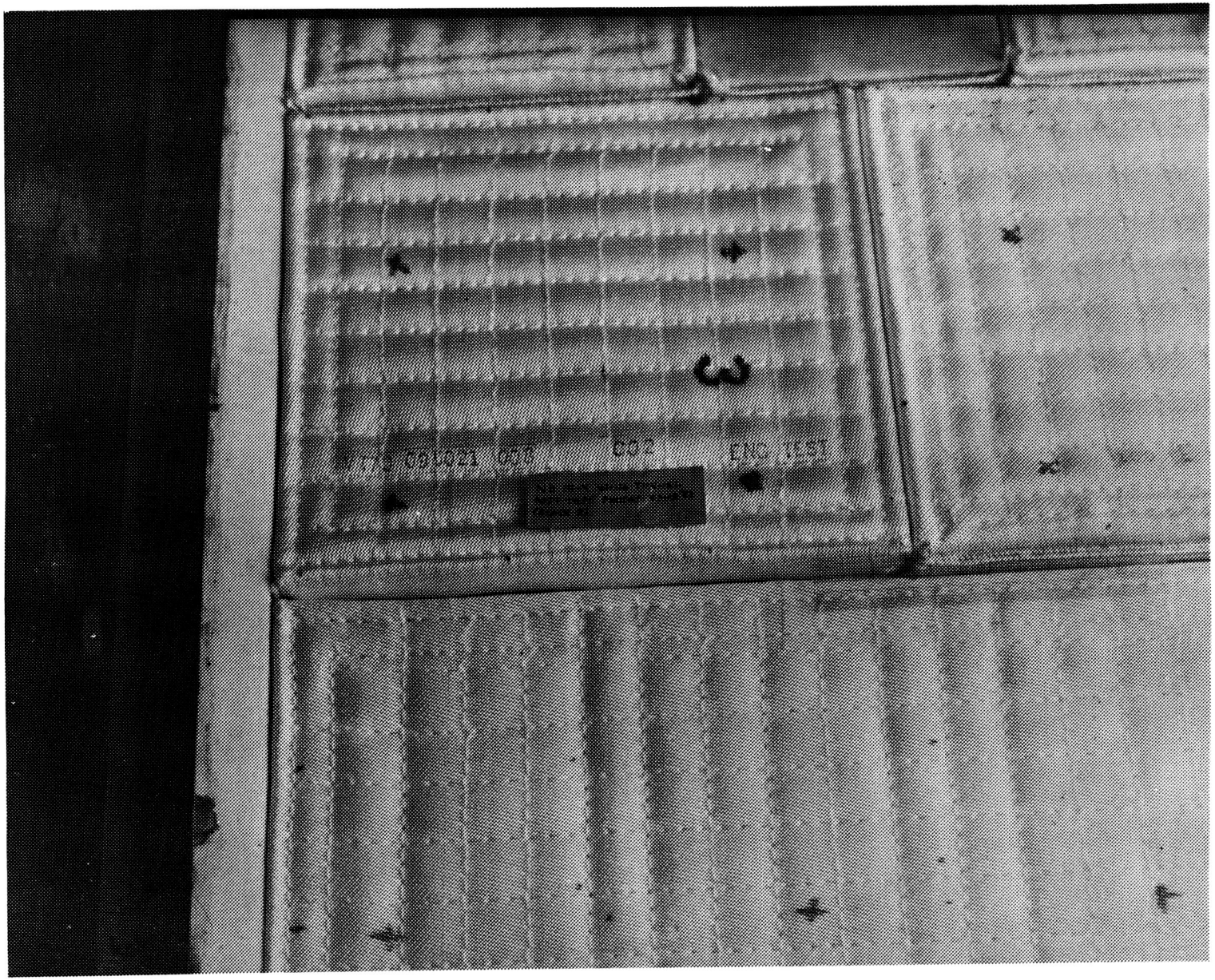
j. Post-Test OS-305-3 photograph of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



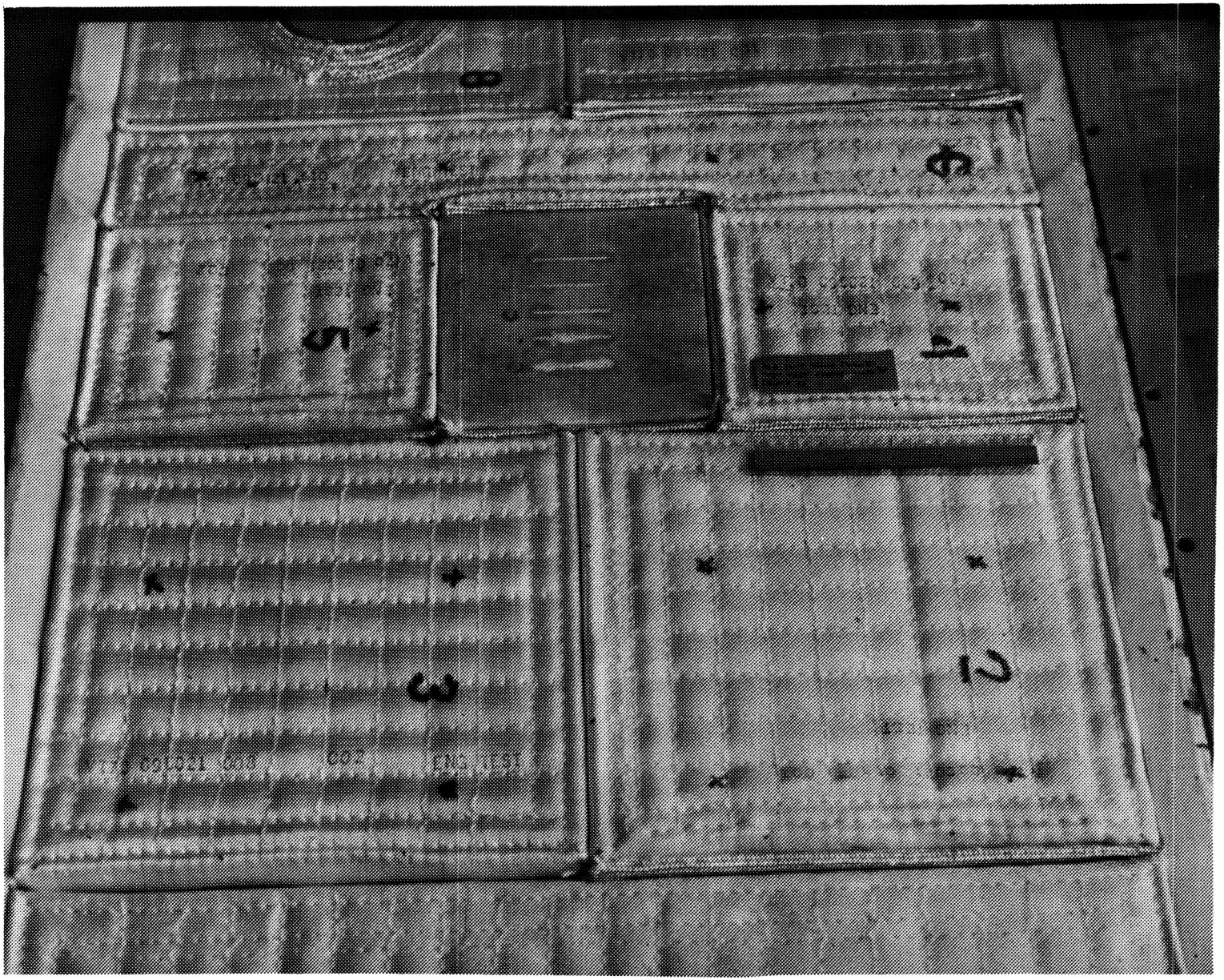
k. Post-Test OS-305-3 close-up photograph of the forward portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued



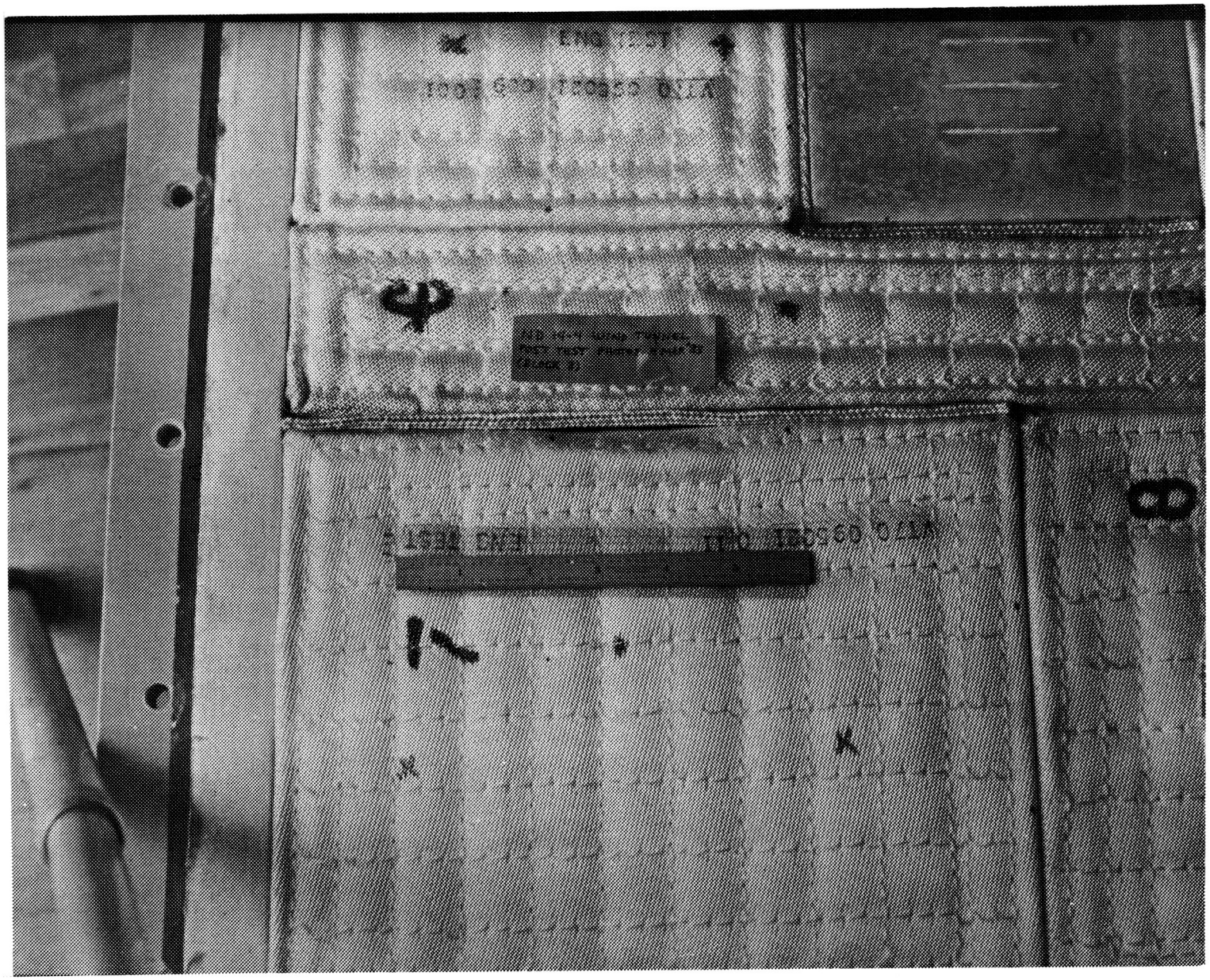
1. Post-Test OS-305-3 close-up photograph of the forward portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



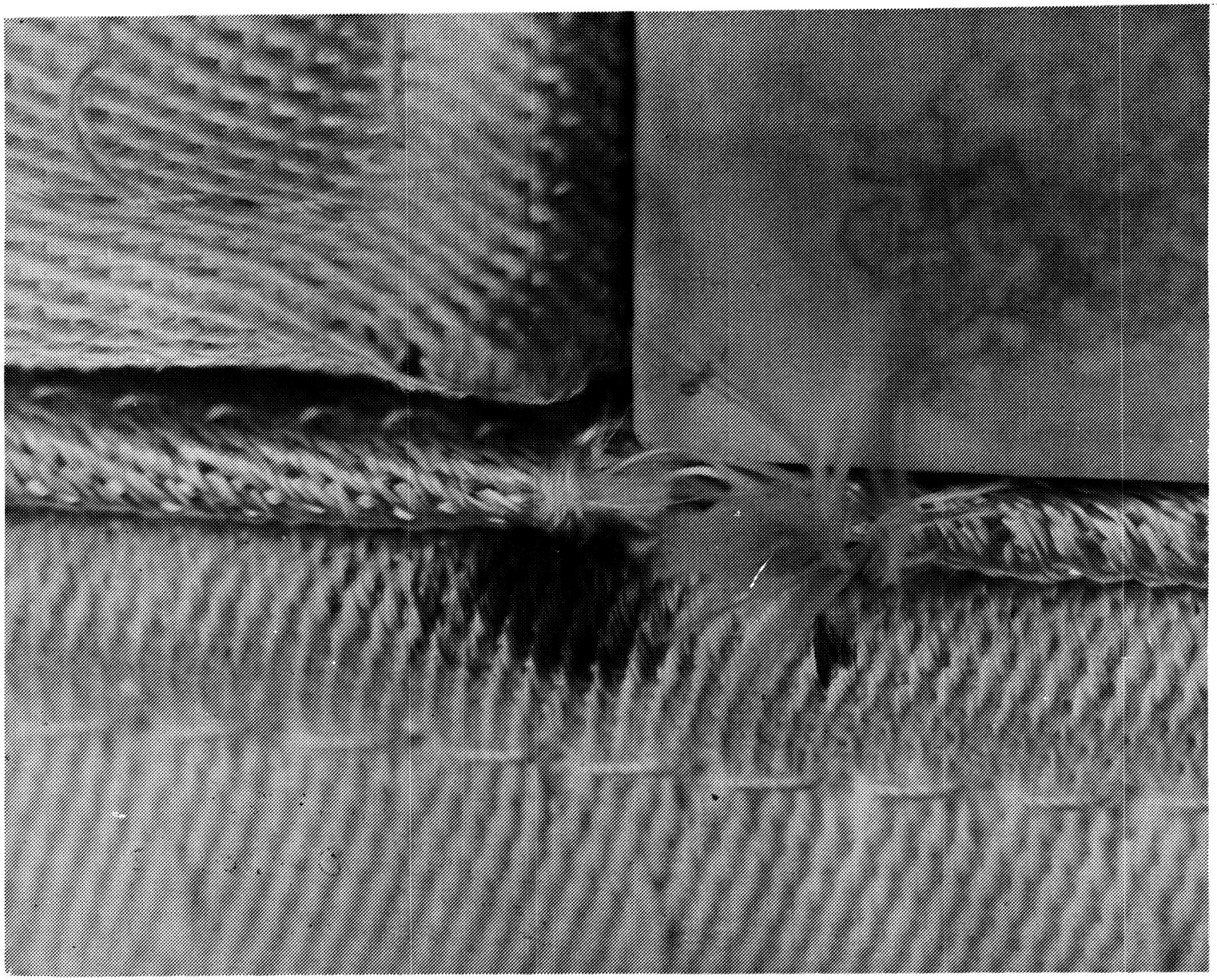
m. Post-Test OS-305-3 close-up photograph of the middle portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



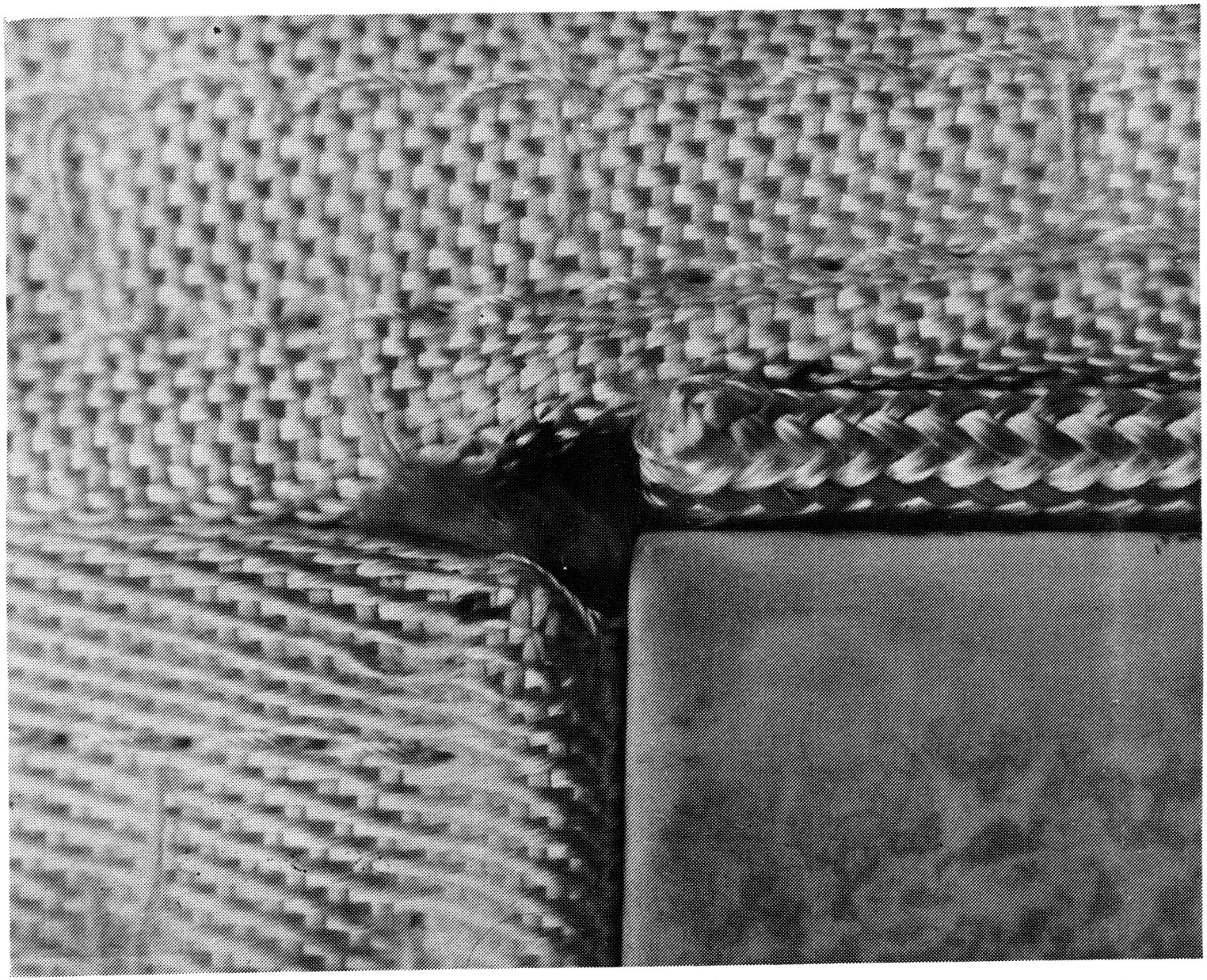
n. Post-Test OS-305-3 close-up photograph of the middle portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued



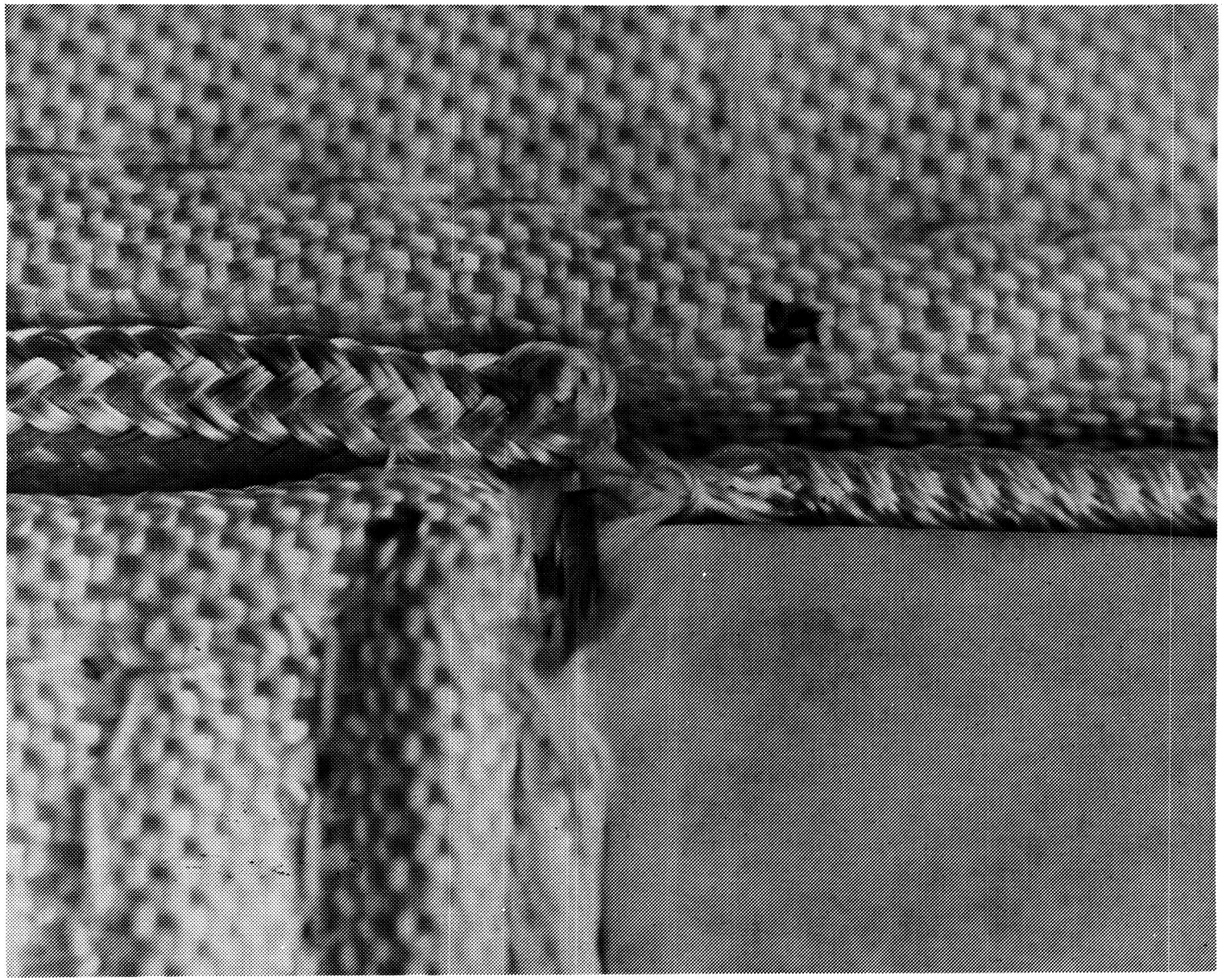
o. Post-Test OS-305-3 close-up photograph of frayed threads surrounding the square-shaped LRSI tile on Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



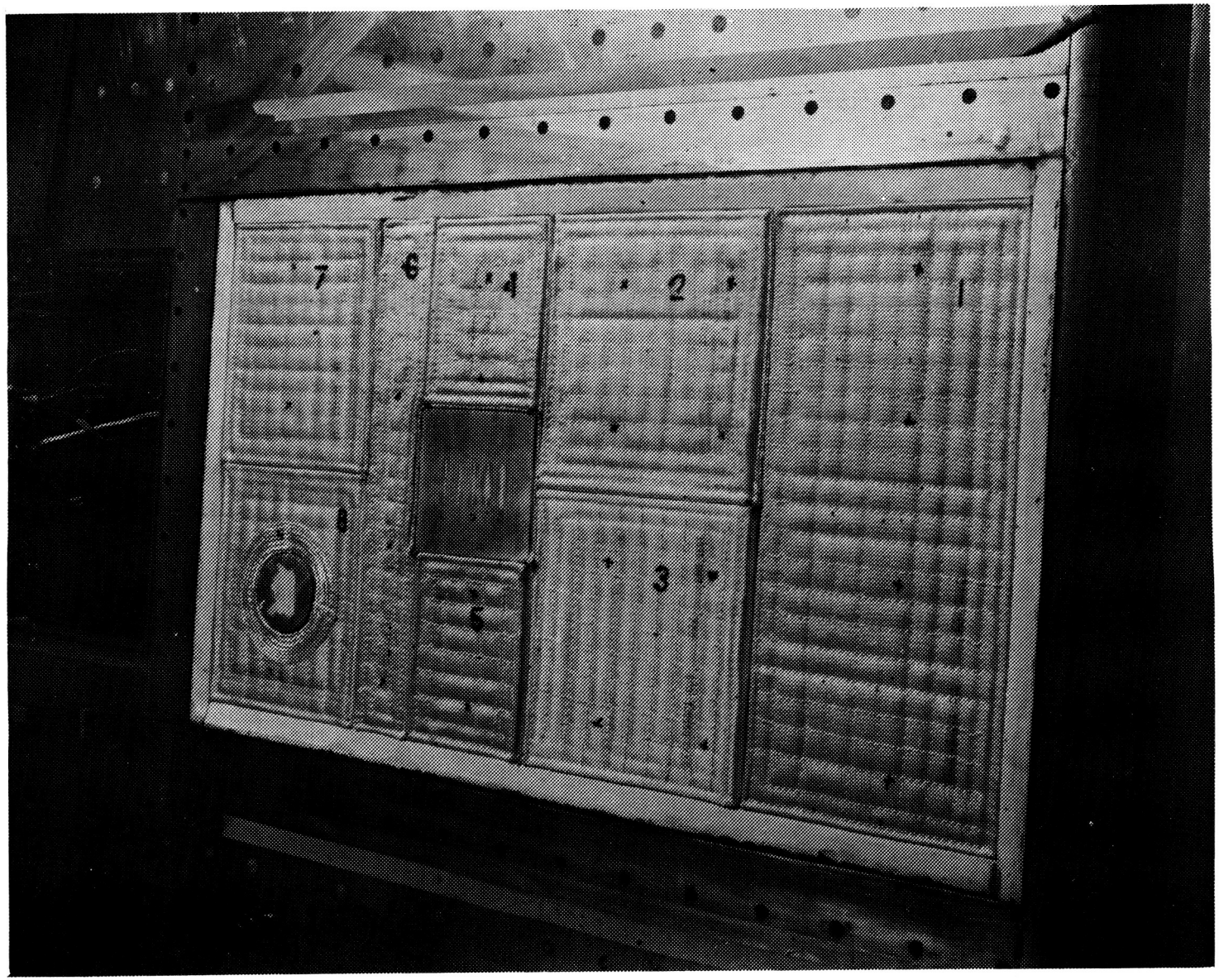
p. Post-Test OS-305-3 close-up photograph of frayed threads surrounding the square-shaped LRSI tile on Model 125-0

Figure 2 (Continued)



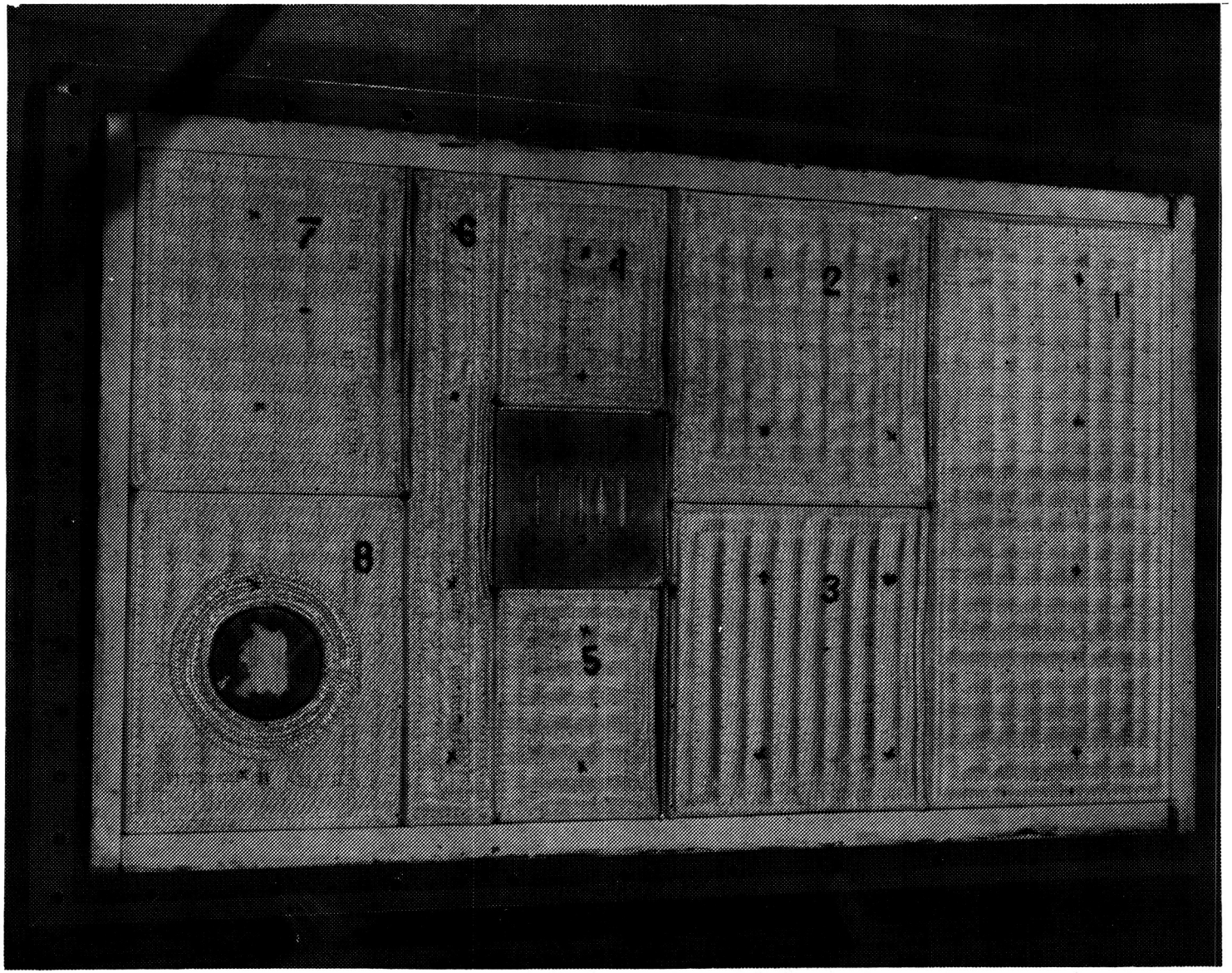
q. Post-Test OS-305-3 close-up photograph of frayed threads surrounding the square-shaped LRSI tile on Model 125-0

Figure 2 (Continued)



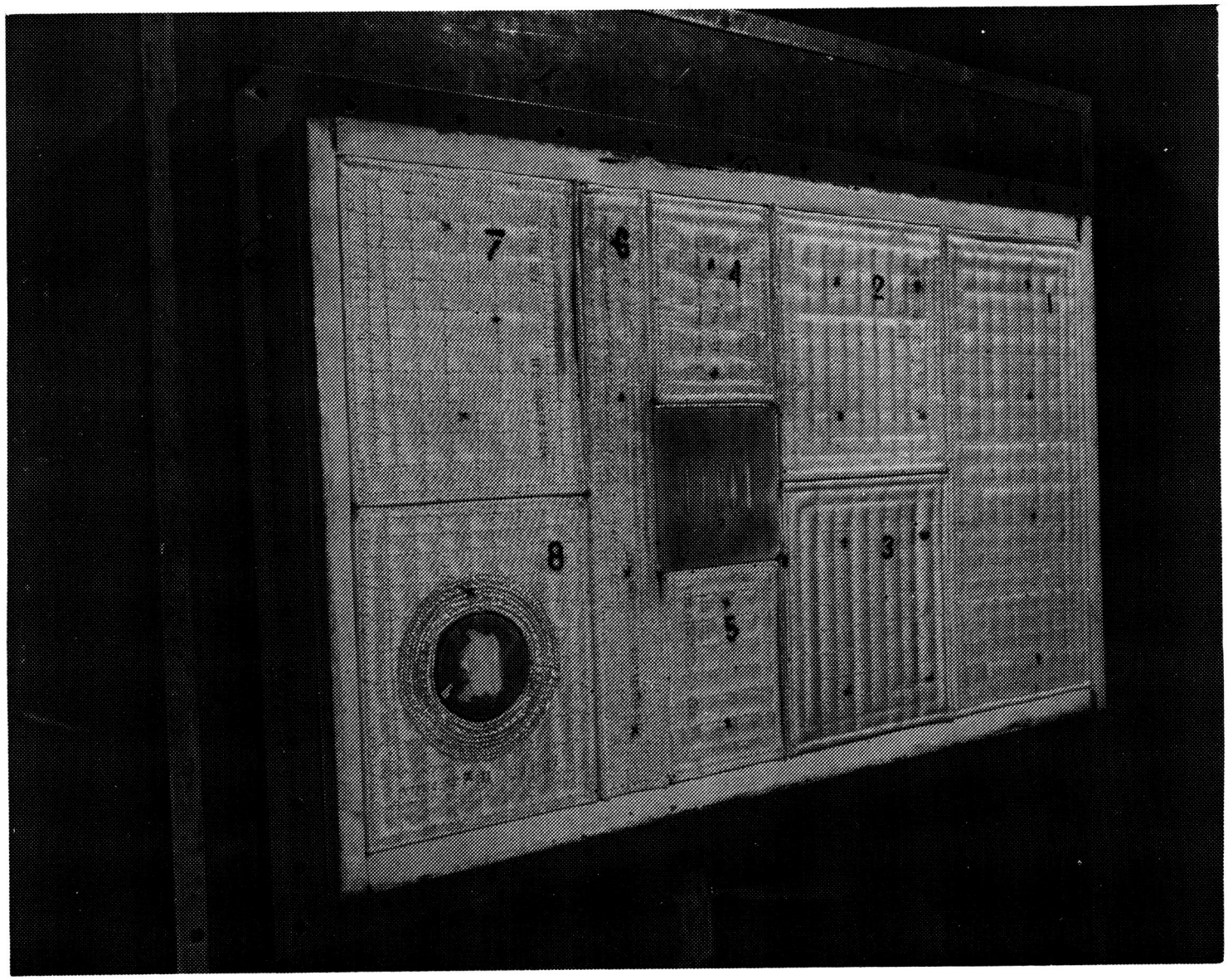
r. Pre-Test OS-305-4 photograph of Model 125-0 (Test Article ND-14-4) installed in the 96-0 test fixture located in the NASA/ARC 11x11-ft Wind Tunnel

Figure 2 (Continued)



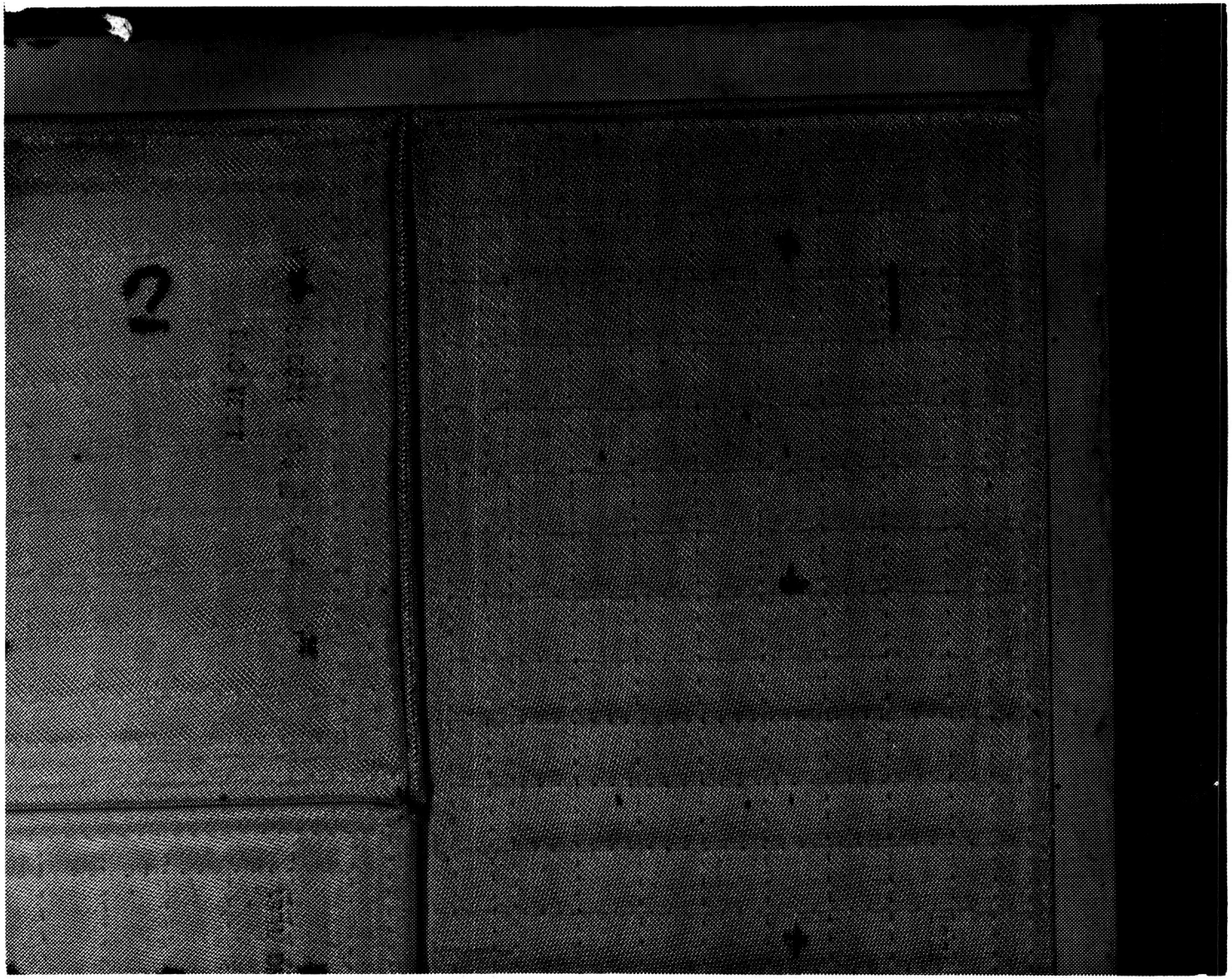
s. Post-Test OS-305-4 photograph of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



t. Post-Test OS-305-4 photograph of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)

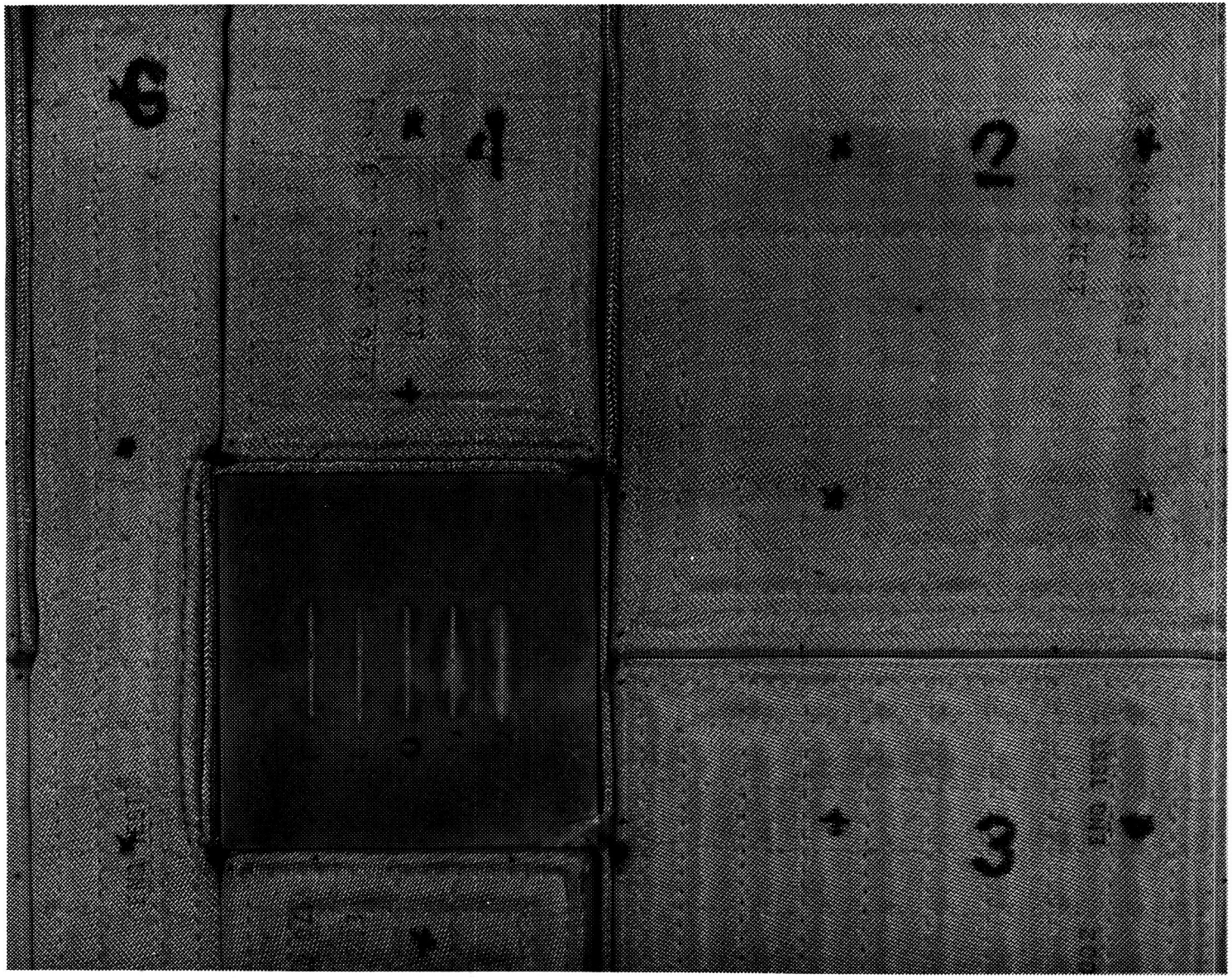


u. Post-Test OS-305-4 close-up photograph of the forward portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)

v. Post-Test OS-305-4 close-up photograph of the forward portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



w. Post-Test OS-305-4 close-up photograph of the middle portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)

x. Post-Test OS-305-4 close-up photograph of the middle portion of Model 125-0 (Test Article ND-14-4)

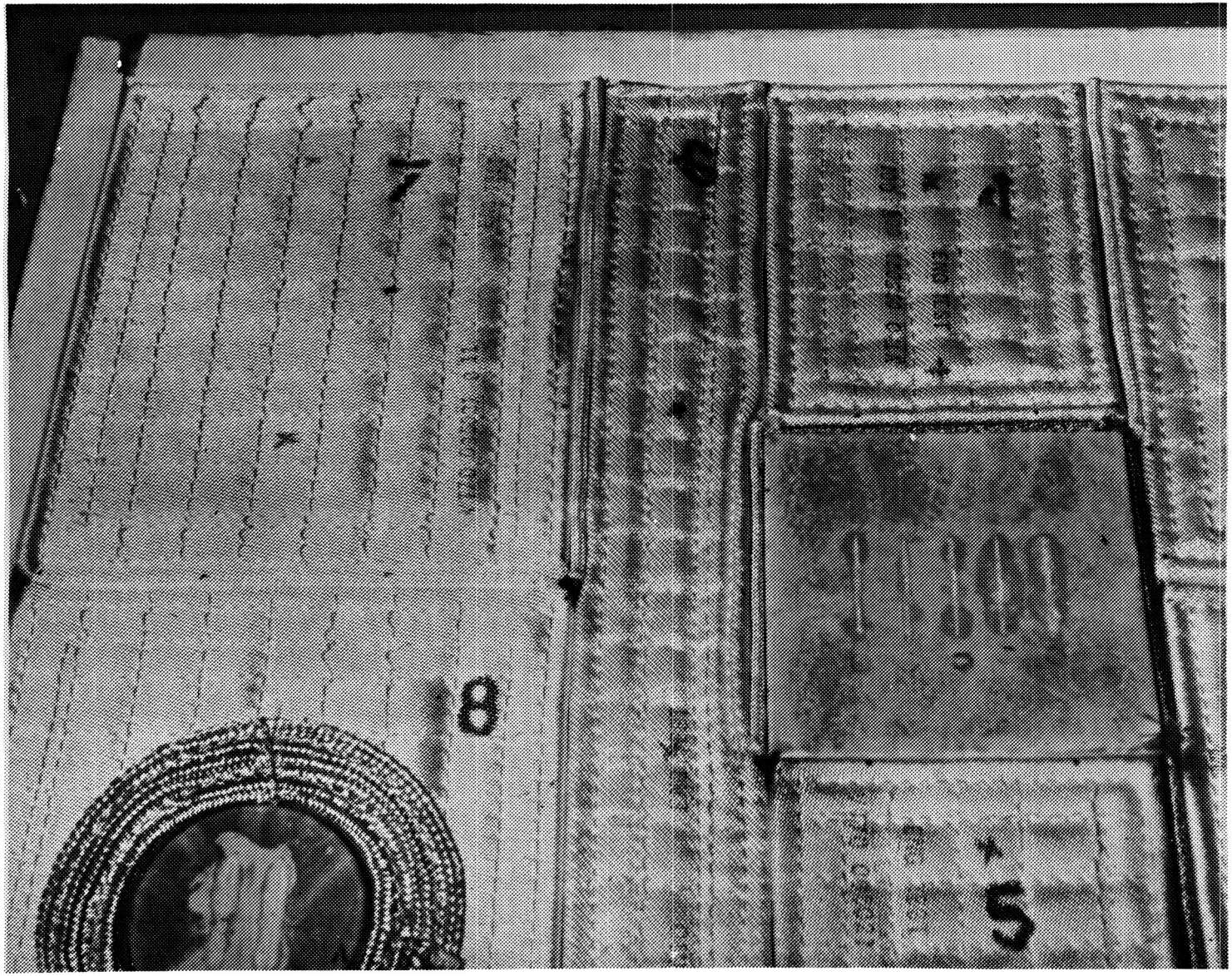
Figure 2 (Continued)

y. Post-Test OS-305-4 close-up photograph of the aft portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)

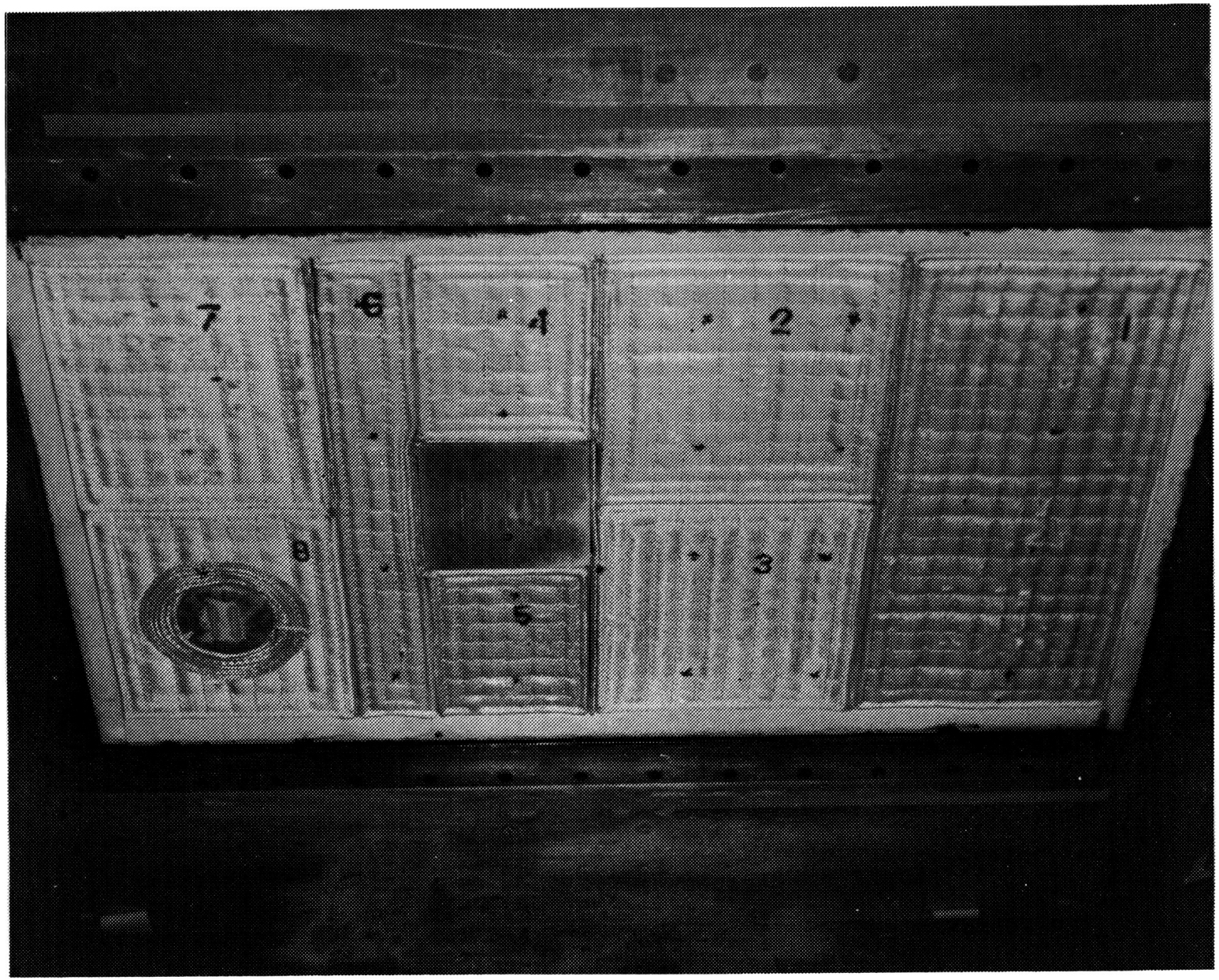
z. Post-Test OS-305-4 close-up photograph of the aft portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



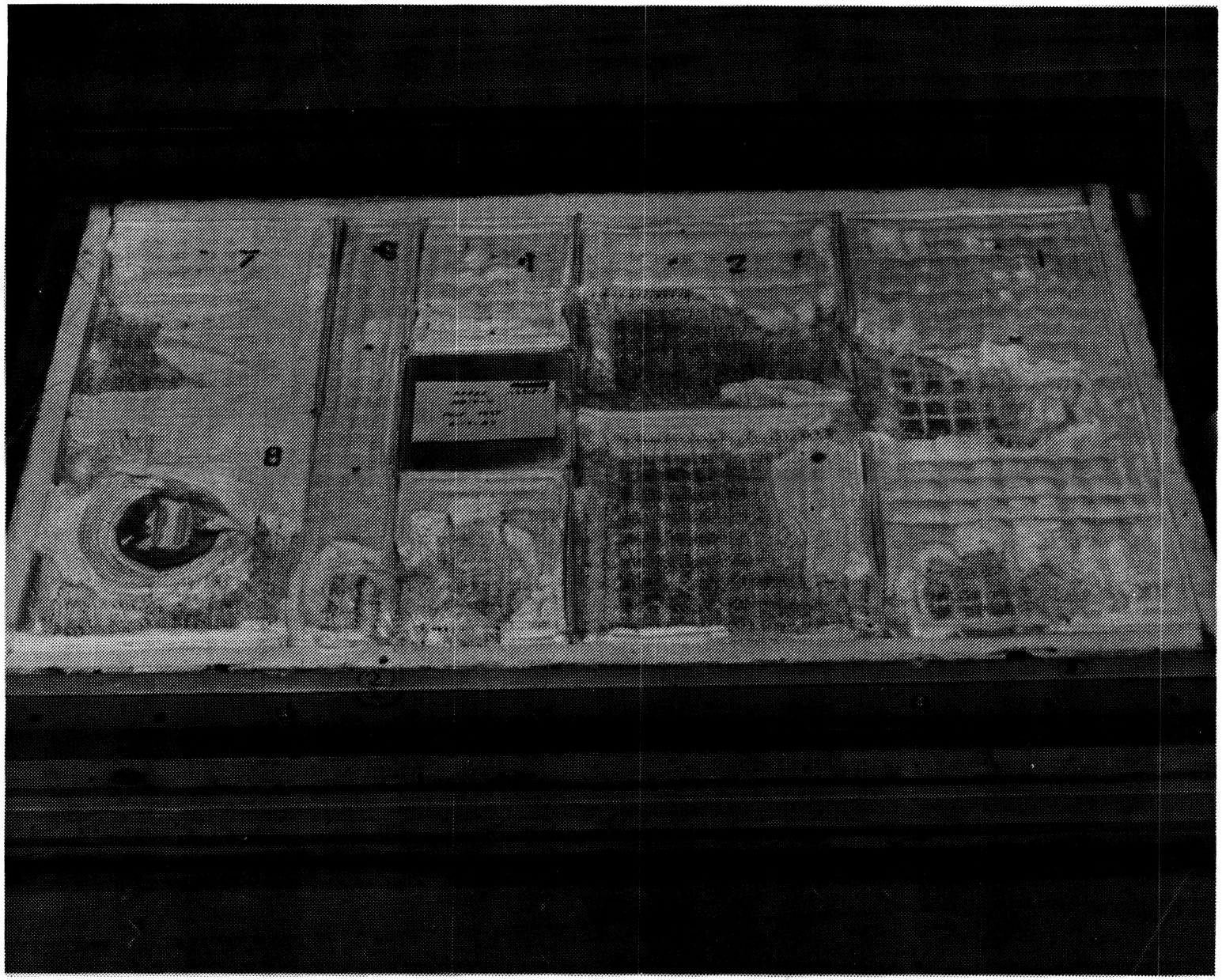
aa. Post-Test OS-305-4 close-up photograph of the middle portion of Model 125-0 (Test Article ND-14-4)

Figure 2 (Continued)



bb. Pre-Test OS-305-5 photograph of Model 125-0 (Test Article ND-14-4) installed in the 96-0 test fixture located in the NASA/ARC 11x11-ft Wind Tunnel

Figure 2 (Continued)



cc. Post-Test OS-305-5 photograph of the failed Model 125-0 (Test Article ND-14-4)

Figure 2 (Concluded)

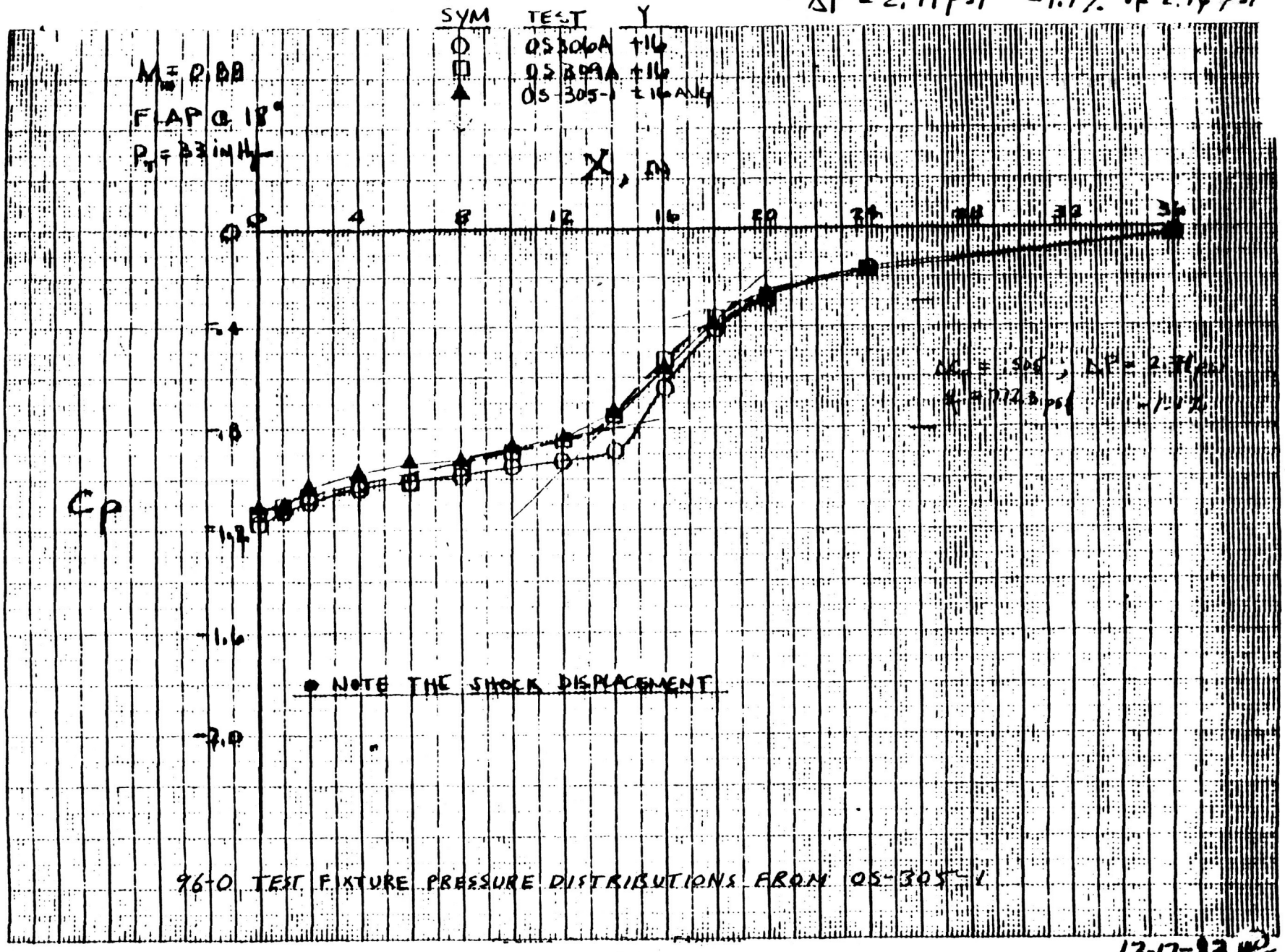


Figure 3a. Data Figures

12-17-82
1-4-83

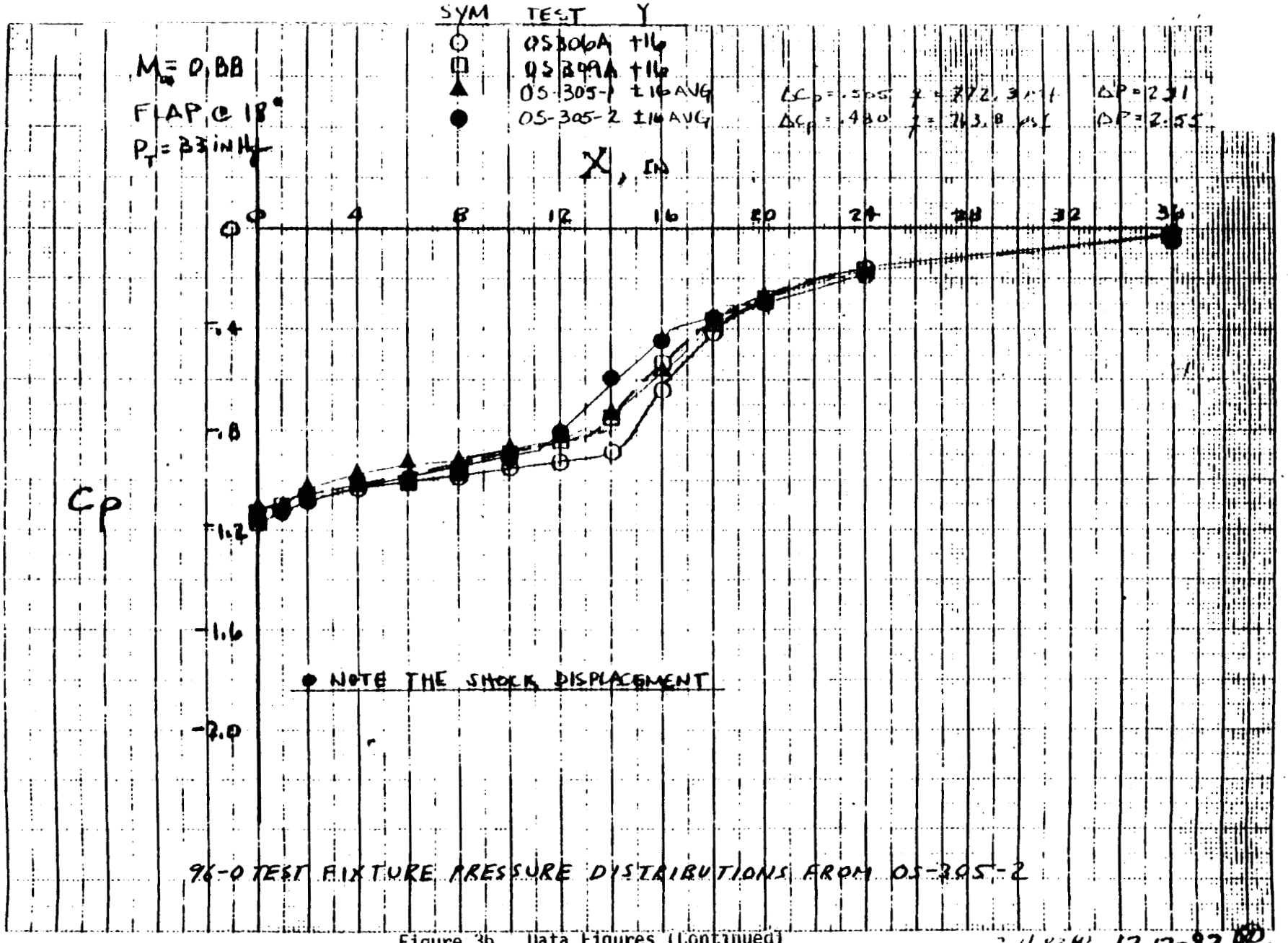


Figure 3b. Data Figures (Continued)

12-17-92

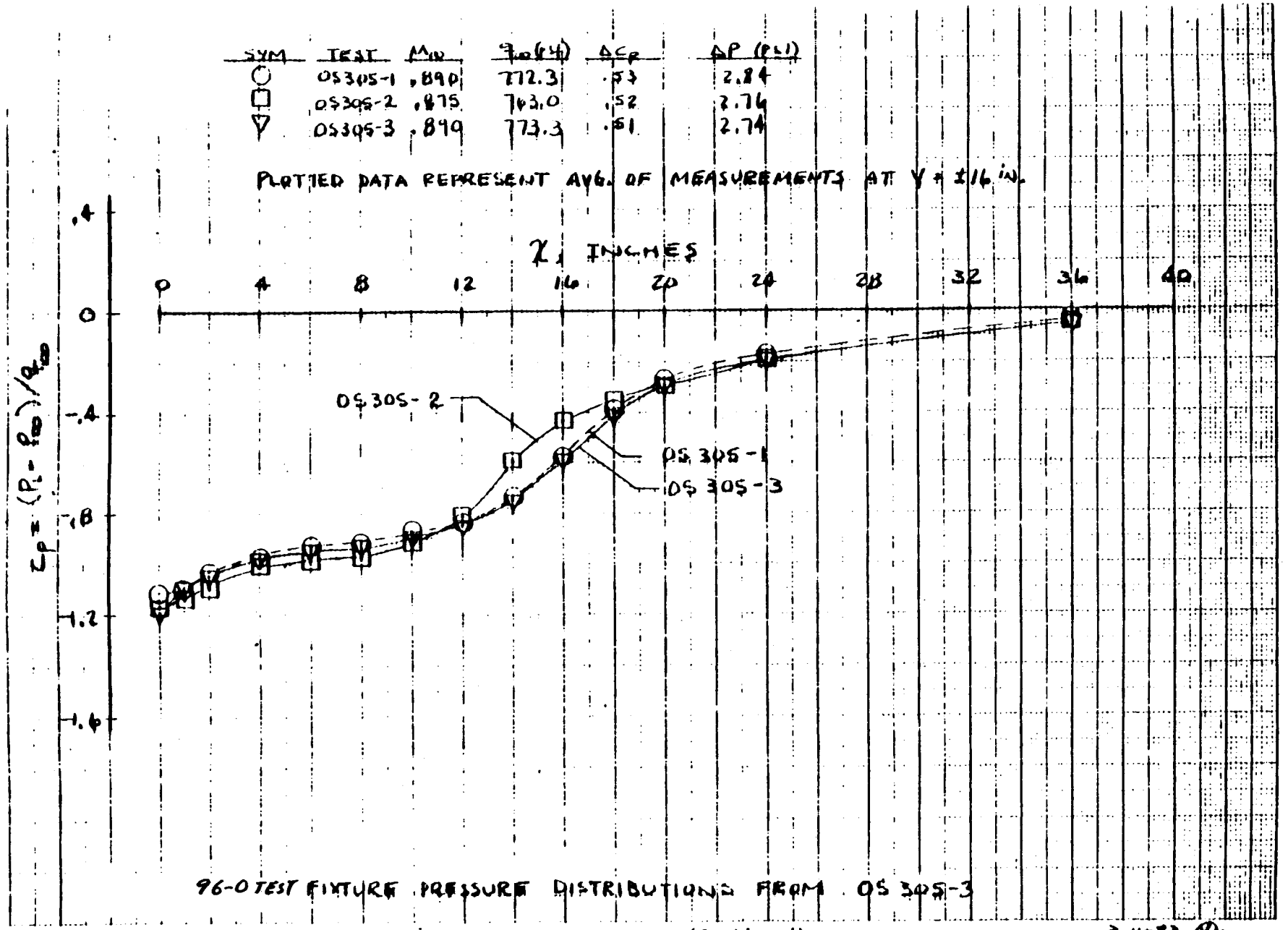


Figure 3c. Data Figures (Continued)

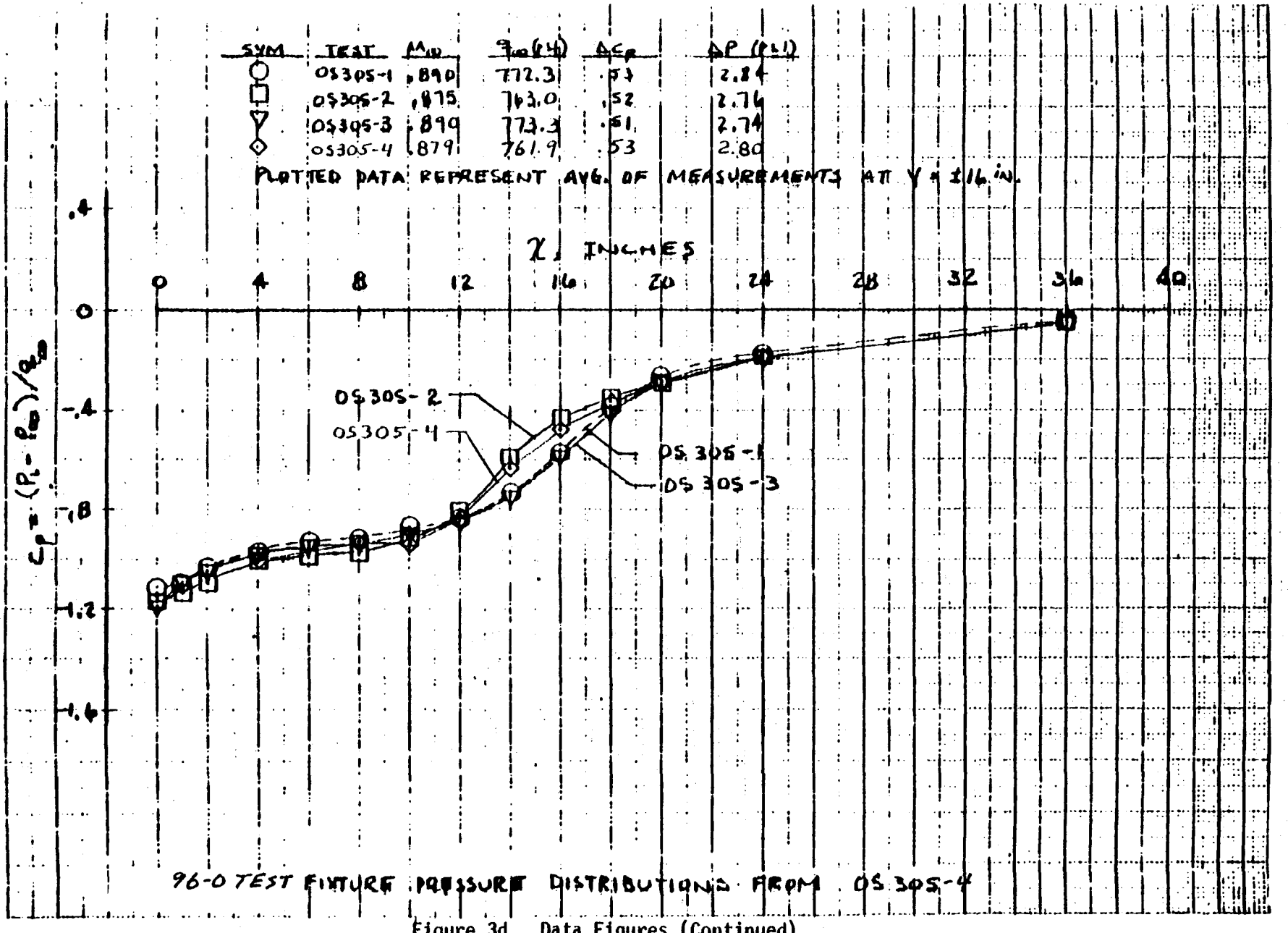


Figure 3d. Data Figures (Continued)

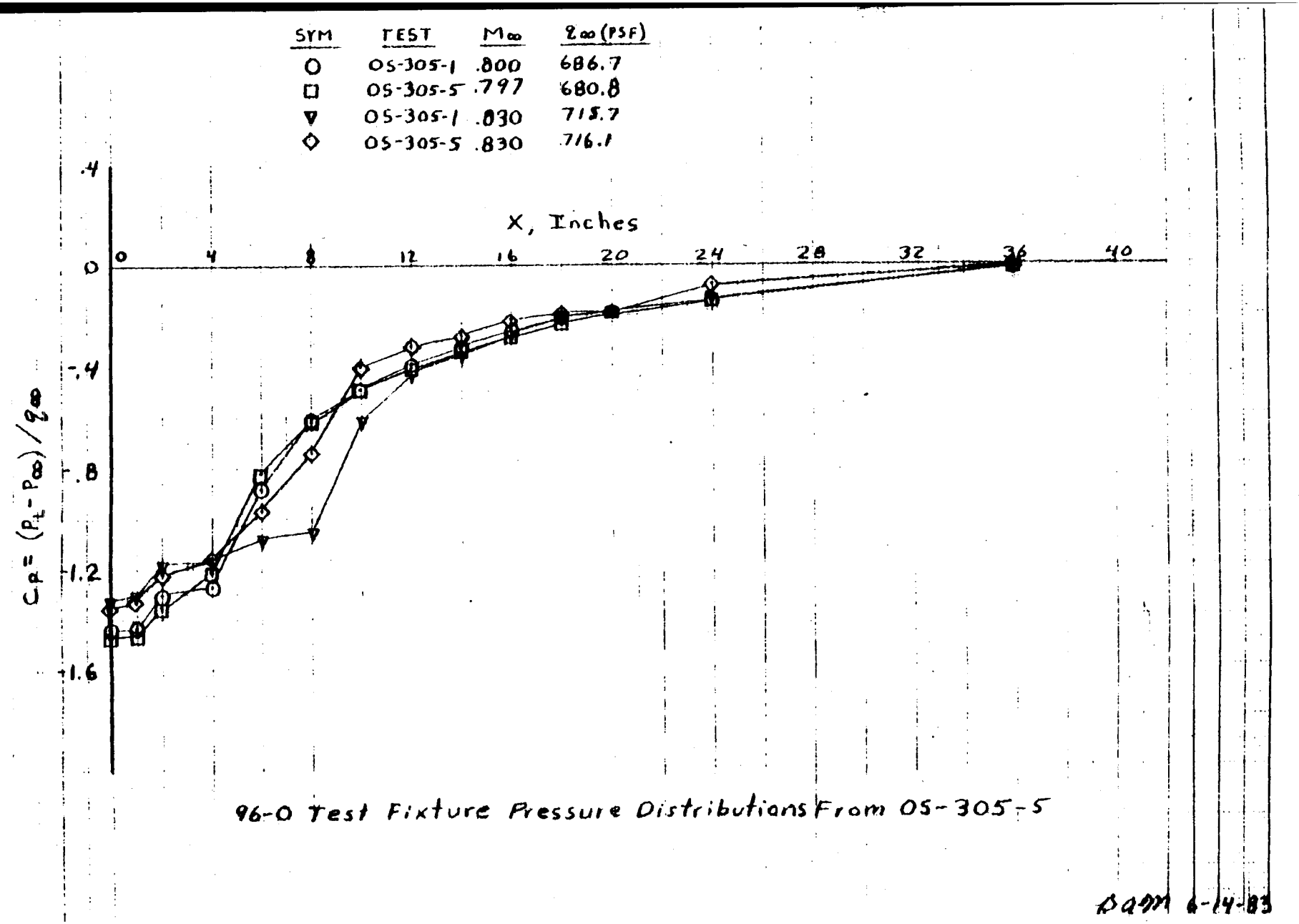


Figure 3e. Data Figures (Concluded)